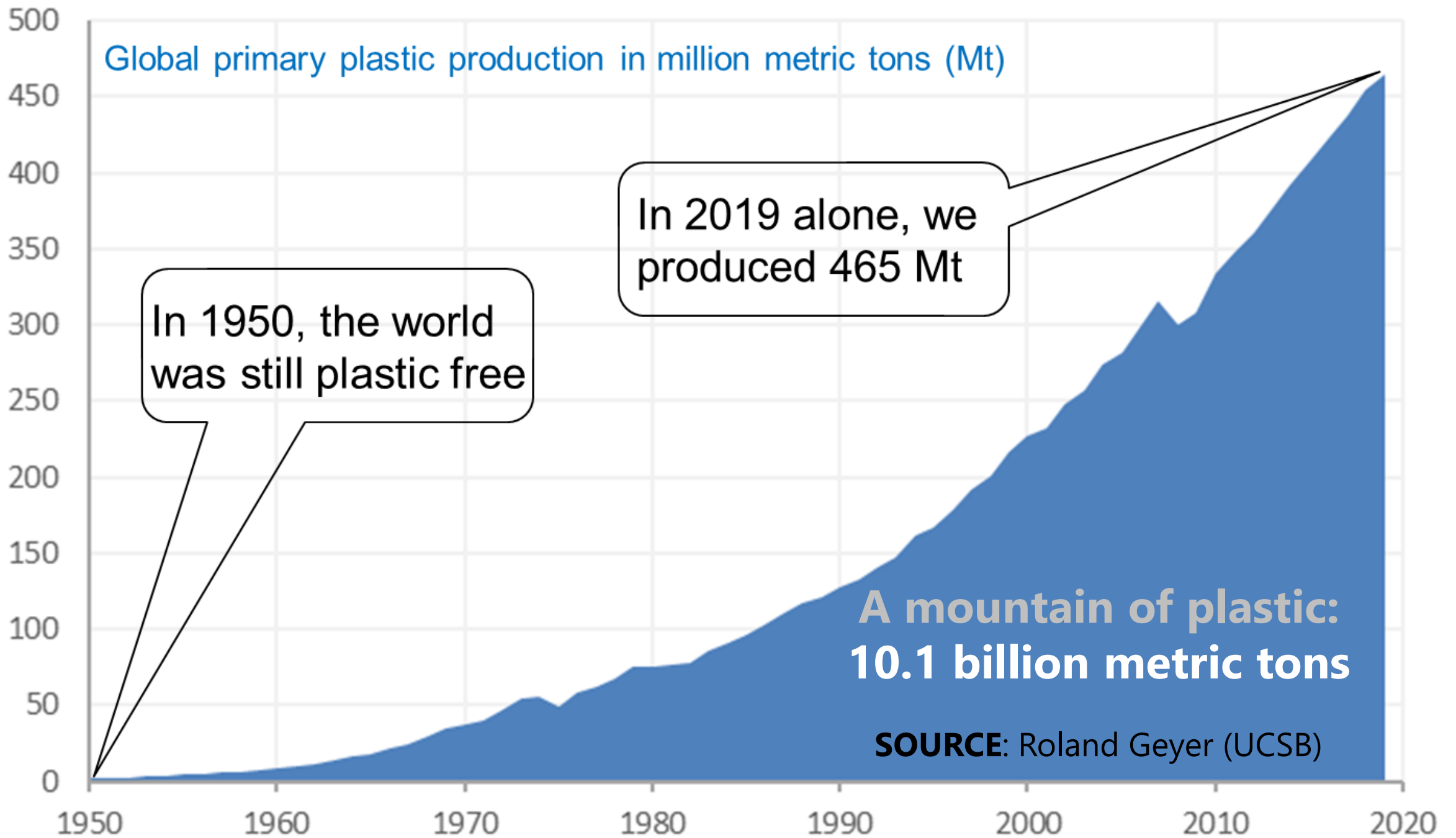


Dr. Sherri “Sam” Mason
Director of Sustainability
Penn State Erie, The Behrend College

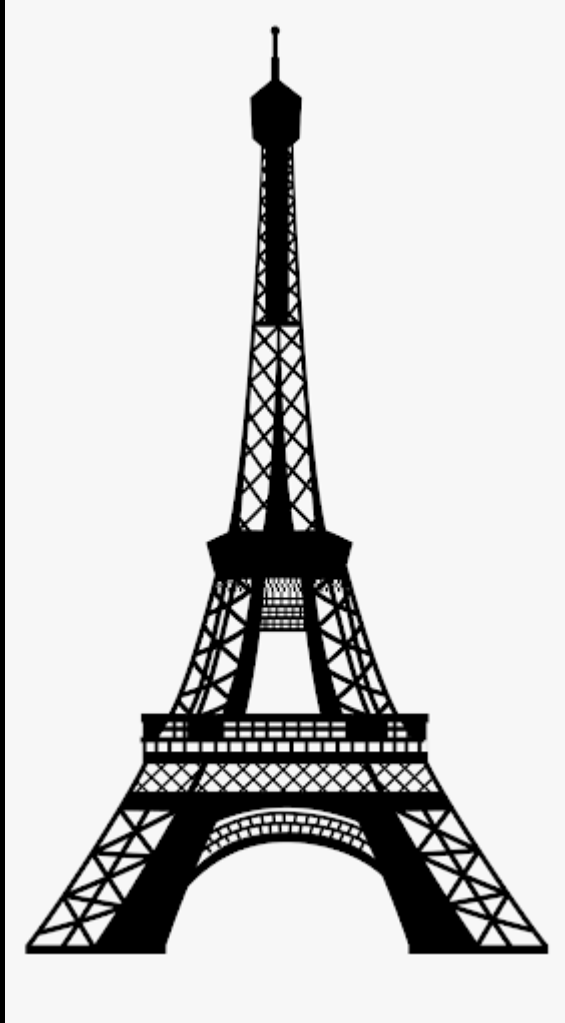
Great Lakes

Plastic Pollution:

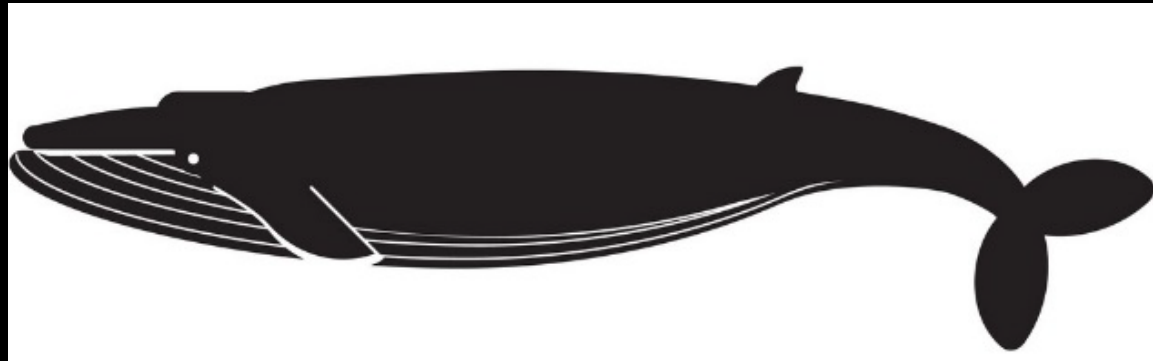
An Overview



How much is 10.1 billion metric tons?



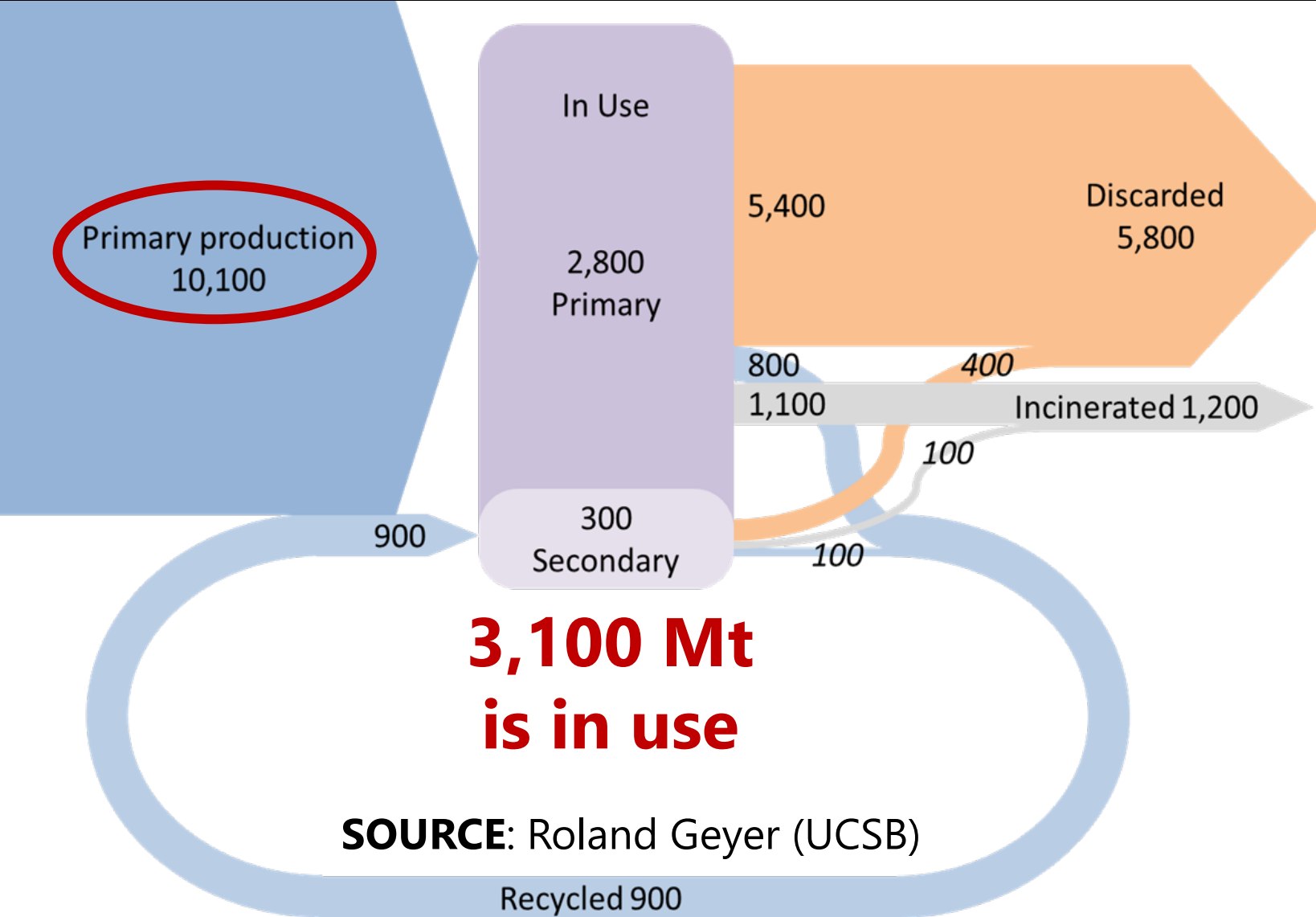
1,000,000



100,000,000

SOURCE:
Roland Geyer (UCSB)

Production, Use & Fate of All Plastic Ever Made (1950-2019)



7,000 Mt of plastic waste generated

74% discarded

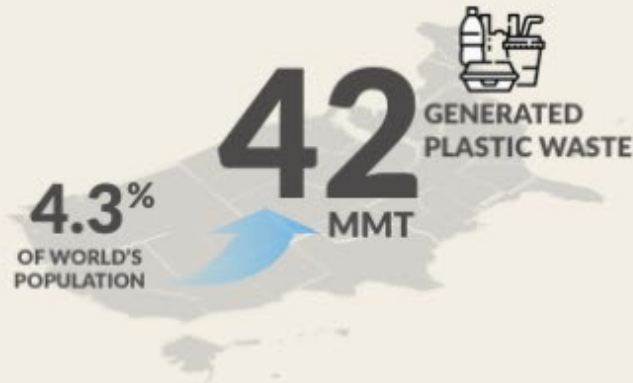
15% incinerated

11% recycled

SOURCE: Roland Geyer (UCSB)

Recycled 900

U.S. PLASTIC WASTE GENERATION



In 2016, the United States generated more plastic waste than any country in the world, with a total of 42 MMT (Law et al. 2020). However, the United States only has 4.3% of the world's population (World Bank 2021). U.S. per capita plastic waste generation is 130 kg/year, which is about 2-8 times higher than many other countries (Law et al. 2020).

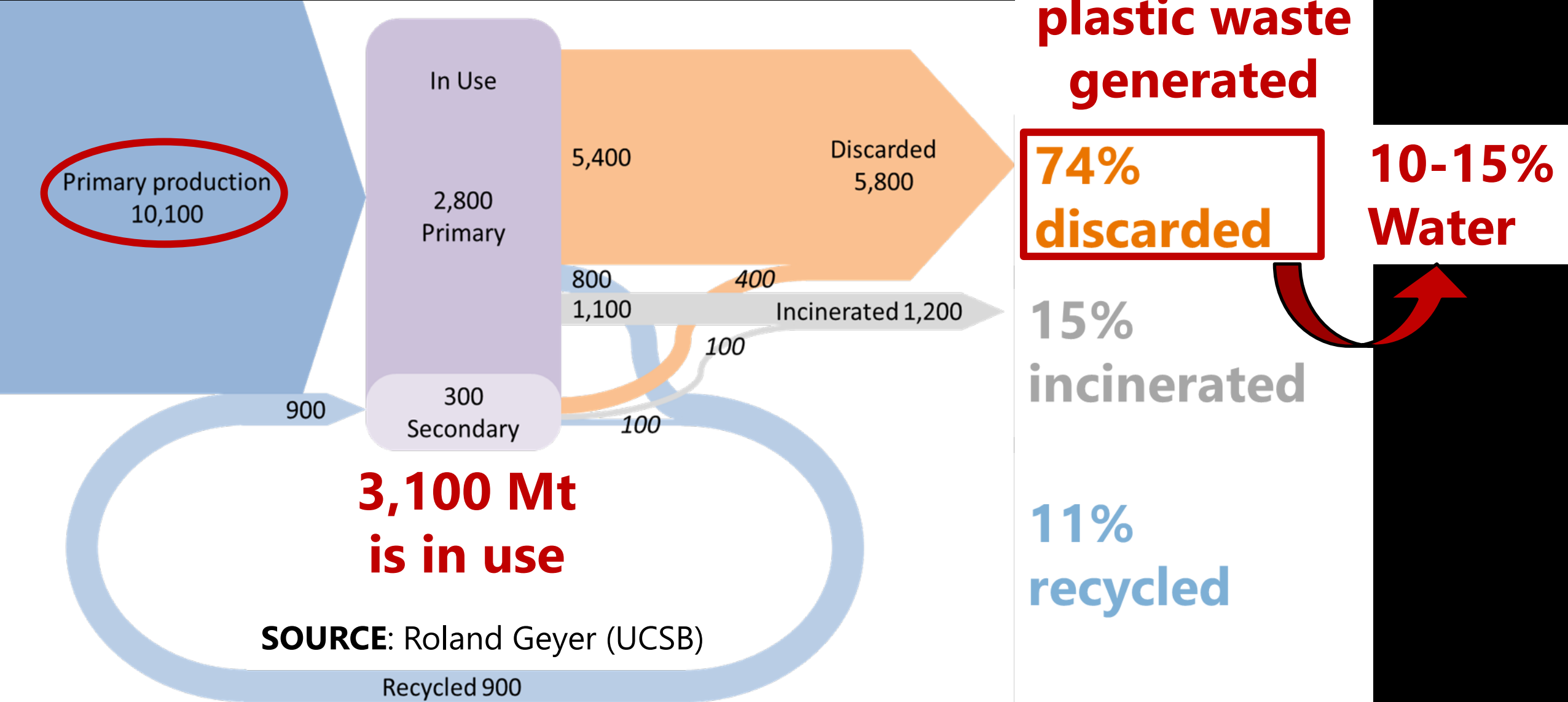
Table 1. Countries with the highest plastic waste generation in 2016. Calculations using data reported in (18), with a refined estimate for the United States (bold text). EU-28 countries are reported collectively (italics).

Country	Plastic waste generation (metric tons)	Total waste generation (metric tons)	% Plastic in solid waste	2016 Population (millions)	Per capita plastic waste generation (kg/year)
United States	42,027,215	320,818,436	13.1	323.1	130.09
United States	34,020,748	263,726,732	12.9	323.1	105.30
<i>EU-28</i>	<i>29,890,143</i>	<i>243,737,466</i>	<i>11.7</i>	<i>511.2</i>	<i>54.56</i>
India	26,327,933	277,136,133	9.5	1,324.5	19.88
China	21,599,465	220,402,706	9.8	1,378.7	15.67
Brazil	10,675,989	79,081,401	13.5	206.2	51.78
Indonesia	9,128,000	65,200,000	14.0	261.6	34.90
Russian Federation	8,467,156	59,585,899	14.2	144.3	58.66
Germany	6,683,412	51,410,863	13.0	82.3	81.16
United Kingdom	6,471,650	32,037,871	20.2	65.6	98.66
Mexico	5,902,490	54,151,287	10.9	123.3	47.86
Japan	4,881,161	44,374,189	11.0	127.0	38.44
Thailand	4,796,494	27,268,302	17.6	69.0	69.54
Korea, Rep.	4,514,186	18,576,898	24.3	51.2	88.09
Italy	3,365,130	29,009,742	11.6	60.6	55.51
Egypt, Arab Rep.	3,037,675	23,366,729	13.0	94.4	32.16
France	2,929,042	32,544,914	9.0	66.9	43.81
Pakistan	2,731,768	30,352,981	9.0	203.6	13.42
Argentina	2,656,771	18,184,606	14.6	43.6	60.95
Algeria	2,092,007	12,378,740	16.9	40.6	51.59
Malaysia	2,058,501	13,723,342	15.0	30.7	67.09
Spain	1,832,533	20,361,483	9.0	46.5	39.42

RECKONING

Glo
Pla

Production, Use & Fate of All Plastic Ever Made (1950-2019)







Overview



Beach
Surveys



Lake
Sediment



Open
Water
Surveys



Biota



Rivers



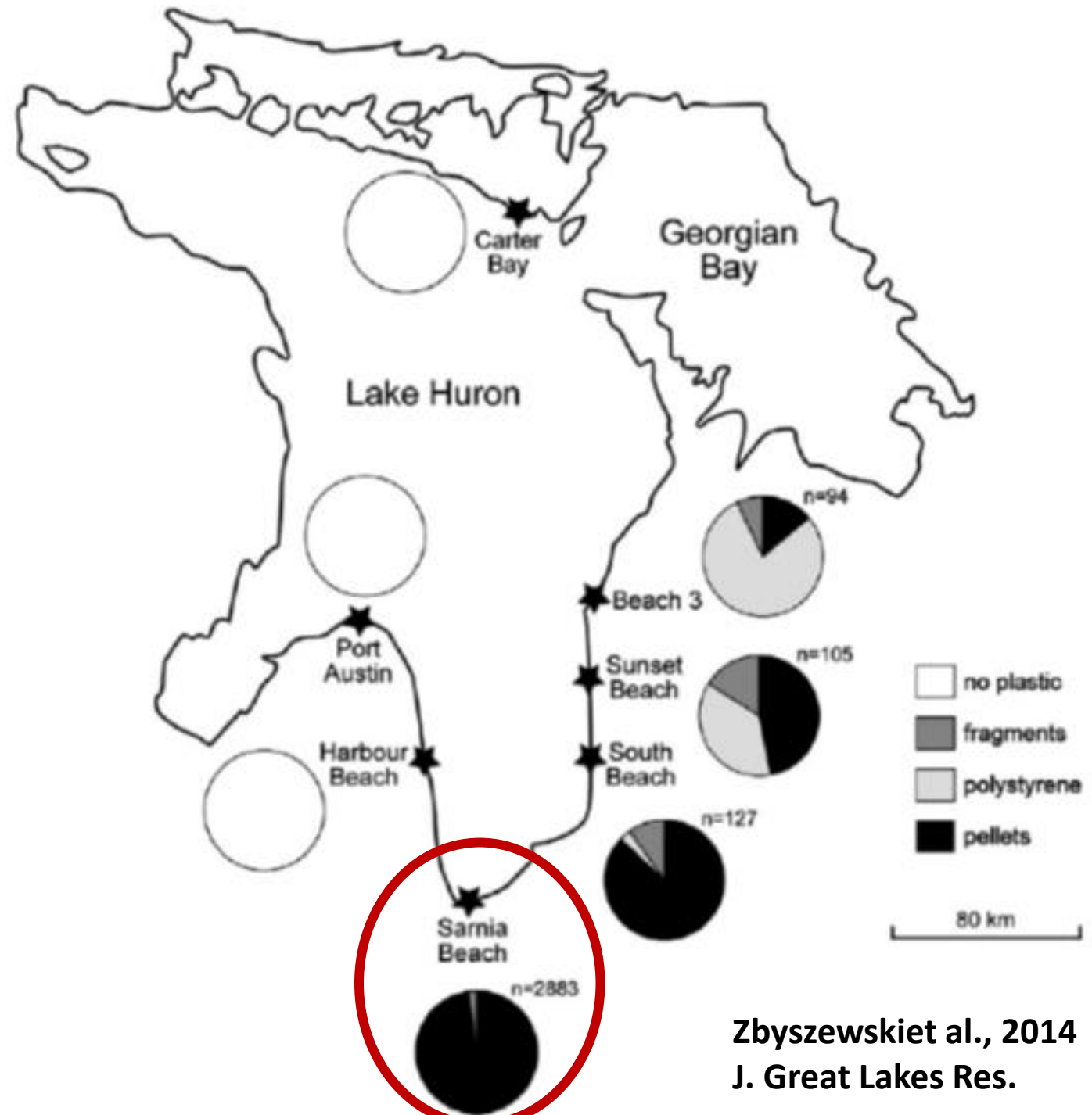
Human
Consumables



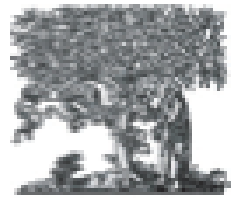
Beach Surveys

Distribution and Degradation of Particles Along the Beaches of L

Maciej Zbyszewski • Patricia L. Corcoran



Zbyszewskiet al., 2014
J. Great Lakes Res.









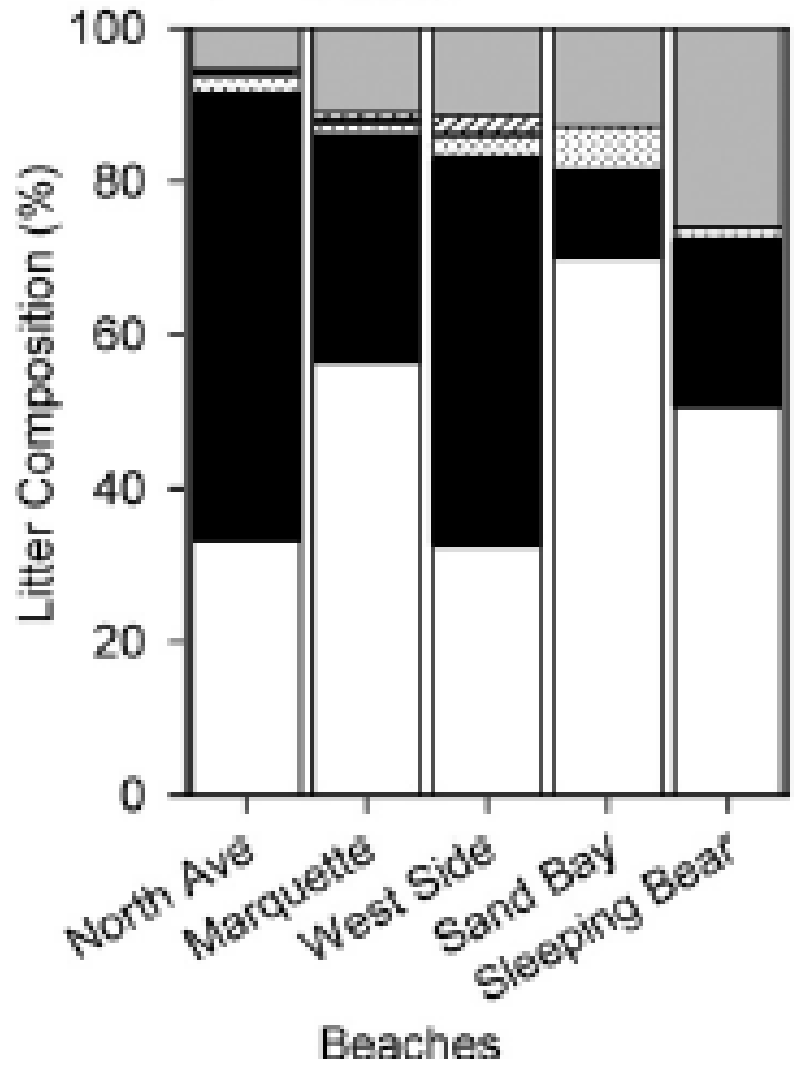
ELSEVIER

Abundance and Michigan beach

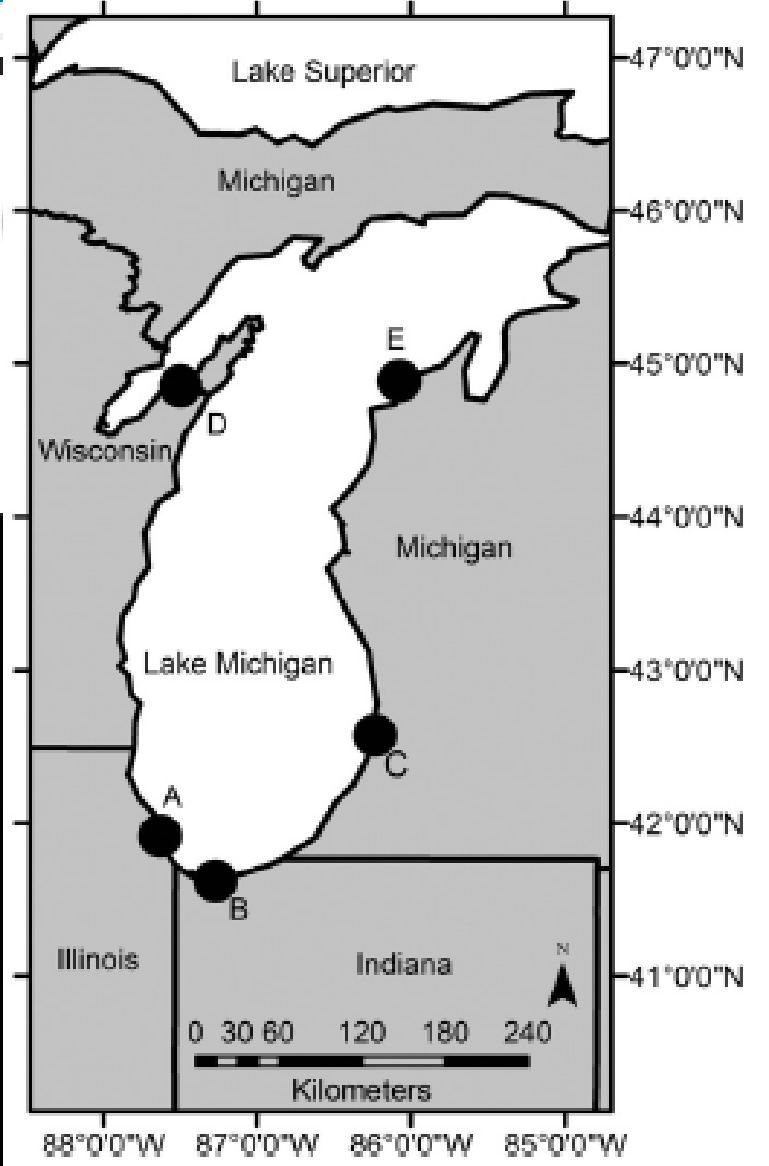
Timothy J. Hoellein

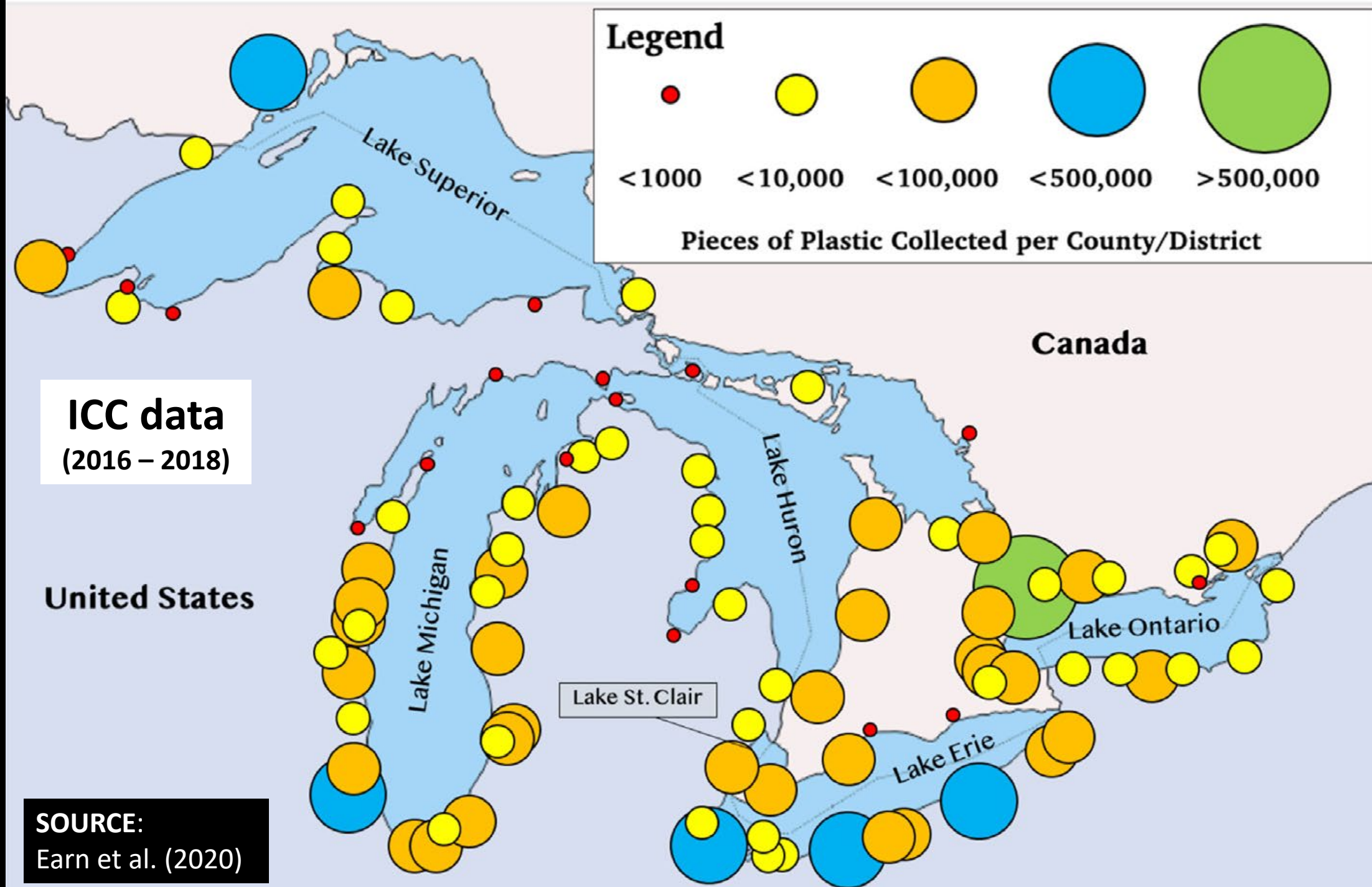
^a Department of Biology, Loyola U
^b Alliance for the Great Lakes, 150
^c Alliance for the Great Lakes, 411

-  Food-related
-  Smoking-related
-  Waterway activities
-  Dumping activities
-  Medical/Personal
-  Other



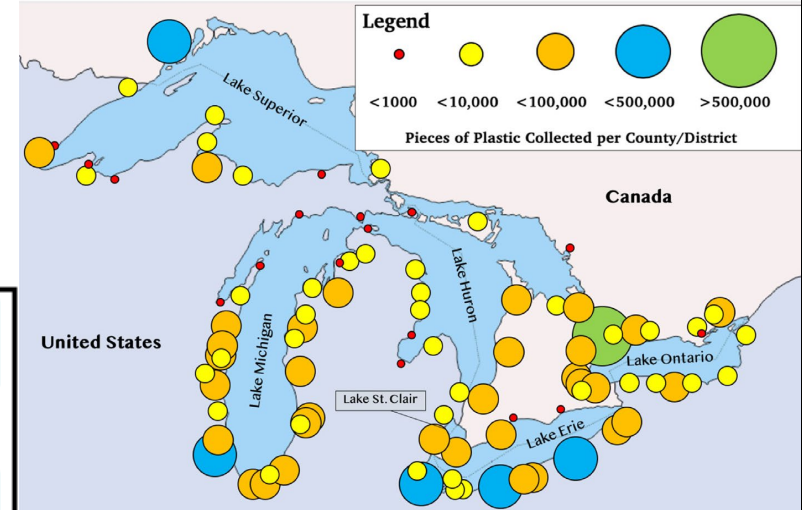
Location on 5 Lake collection






2019 "Dirty Dozen"

12 Most Common Litter Items

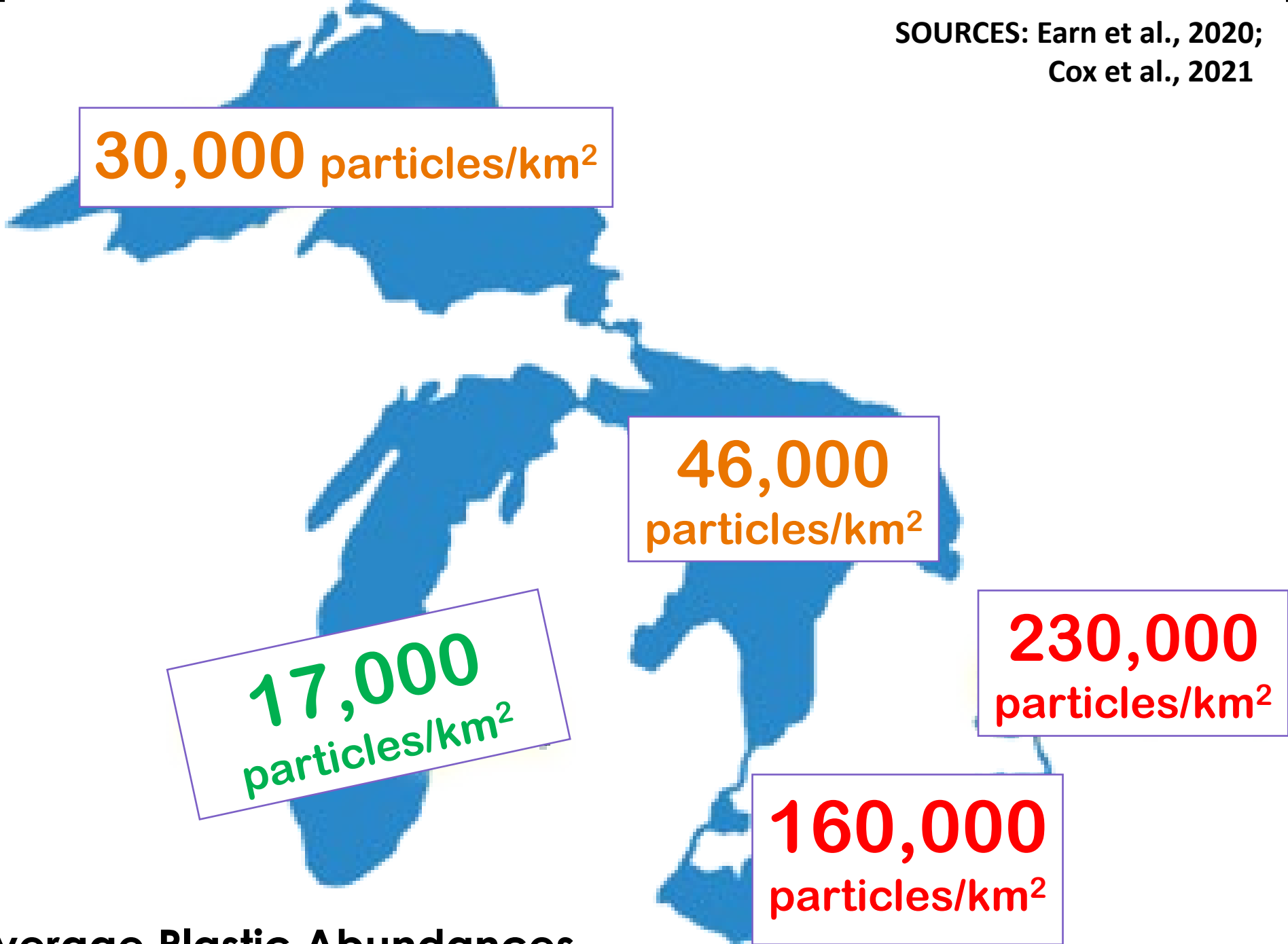


1.	Cigarette Butts	686,055
2.	Tiny Plastic or Foam	595,227
3.	Food Wrappers	74,224
4.	Bottle Caps	51,992
5.	Paper Materials	63,371
6.	Plastic Bags	31,164
7.	Beverage Cans	28,192
8.	Plastic Bottles	26,212
9.	Straws	26,157
10.	Other Packaging	22,470
11.	Foam	24,213
12.	Coffee Cups	17,170

A photograph of a sunset over the ocean. The sun is low on the horizon, creating a bright orange and yellow glow that reflects on the water's surface. The sky is a mix of blue and orange, with some light clouds. The water is dark blue with small ripples.

Open Water Surveys

SOURCES: Earn et al., 2020;
Cox et al., 2021



30,000 particles/km²

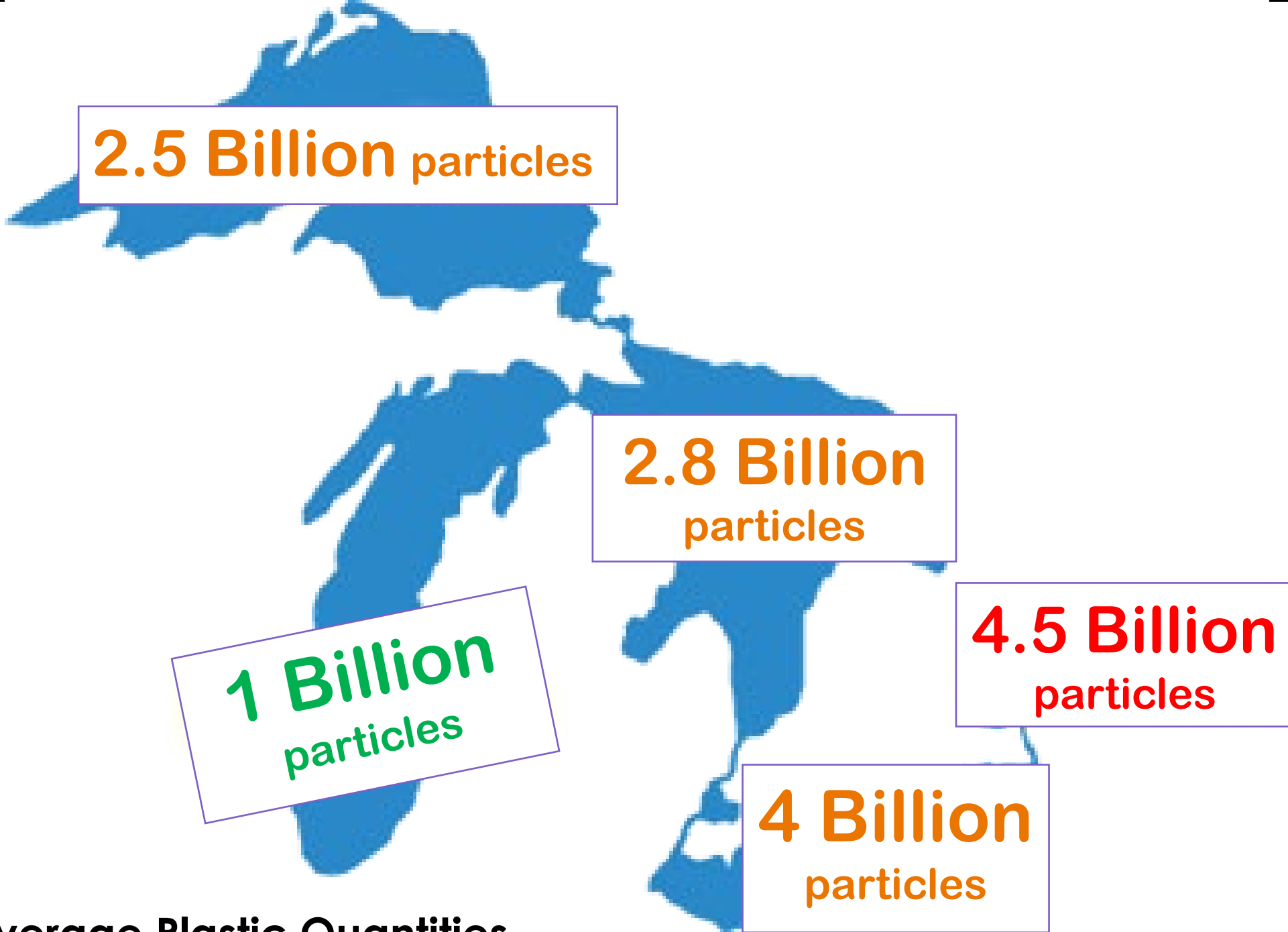
46,000 particles/km²

17,000 particles/km²

230,000 particles/km²

160,000 particles/km²

Average Plastic Abundances



Average Plastic Quantities

MICROPLASTIC

Less than 5 mm

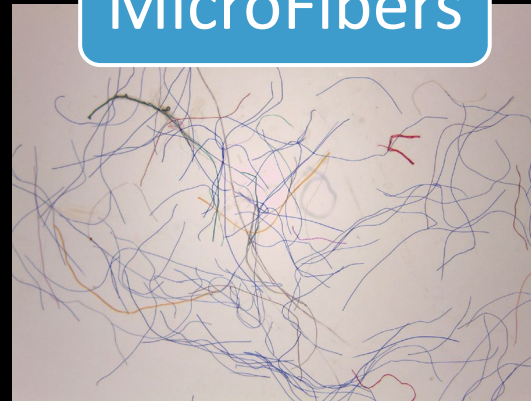
Primary
Microplastics

Pre-Production
Pellets

Microbeads



MicroFibers



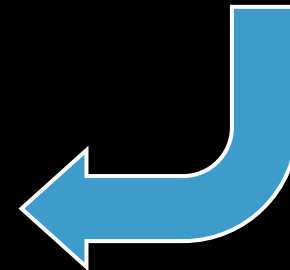
Fragments



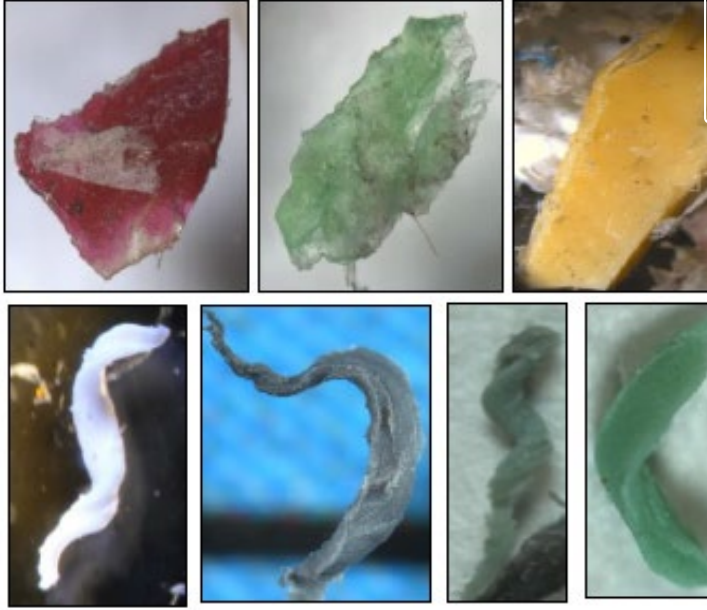
Secondary
Microplastics



Photo-
Degradation



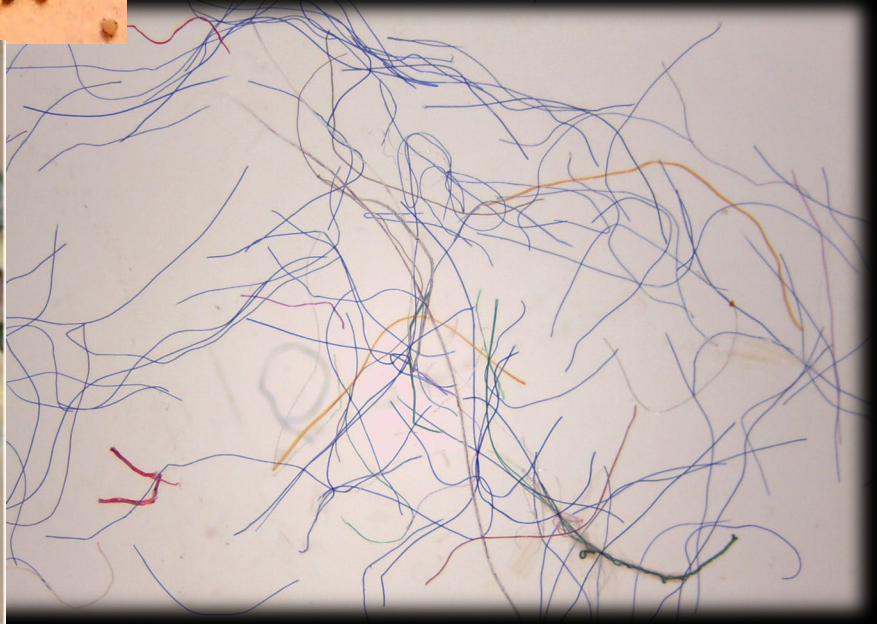
FRAGMENTS



PELLETS

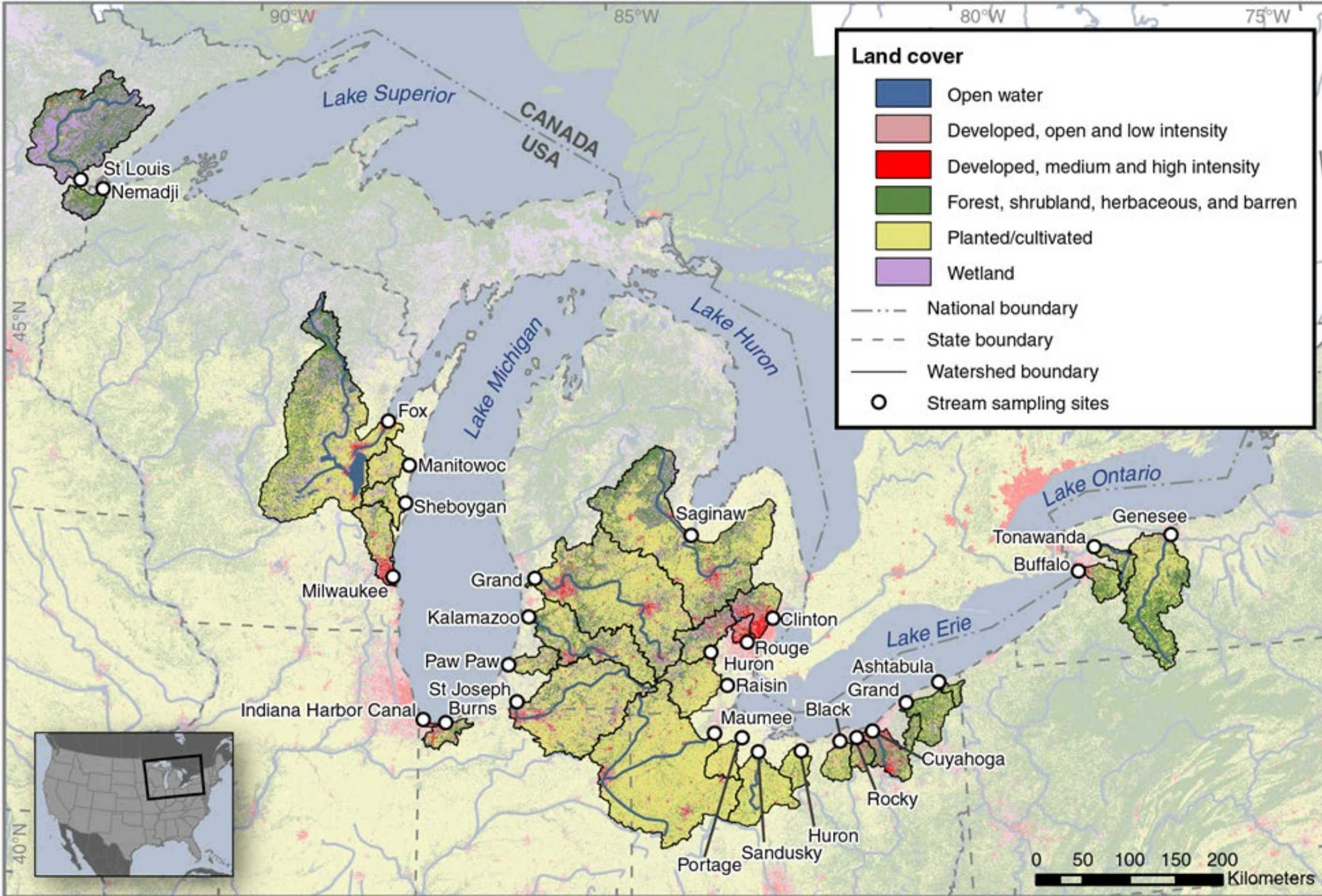


FIBERS/LINES



Rivers



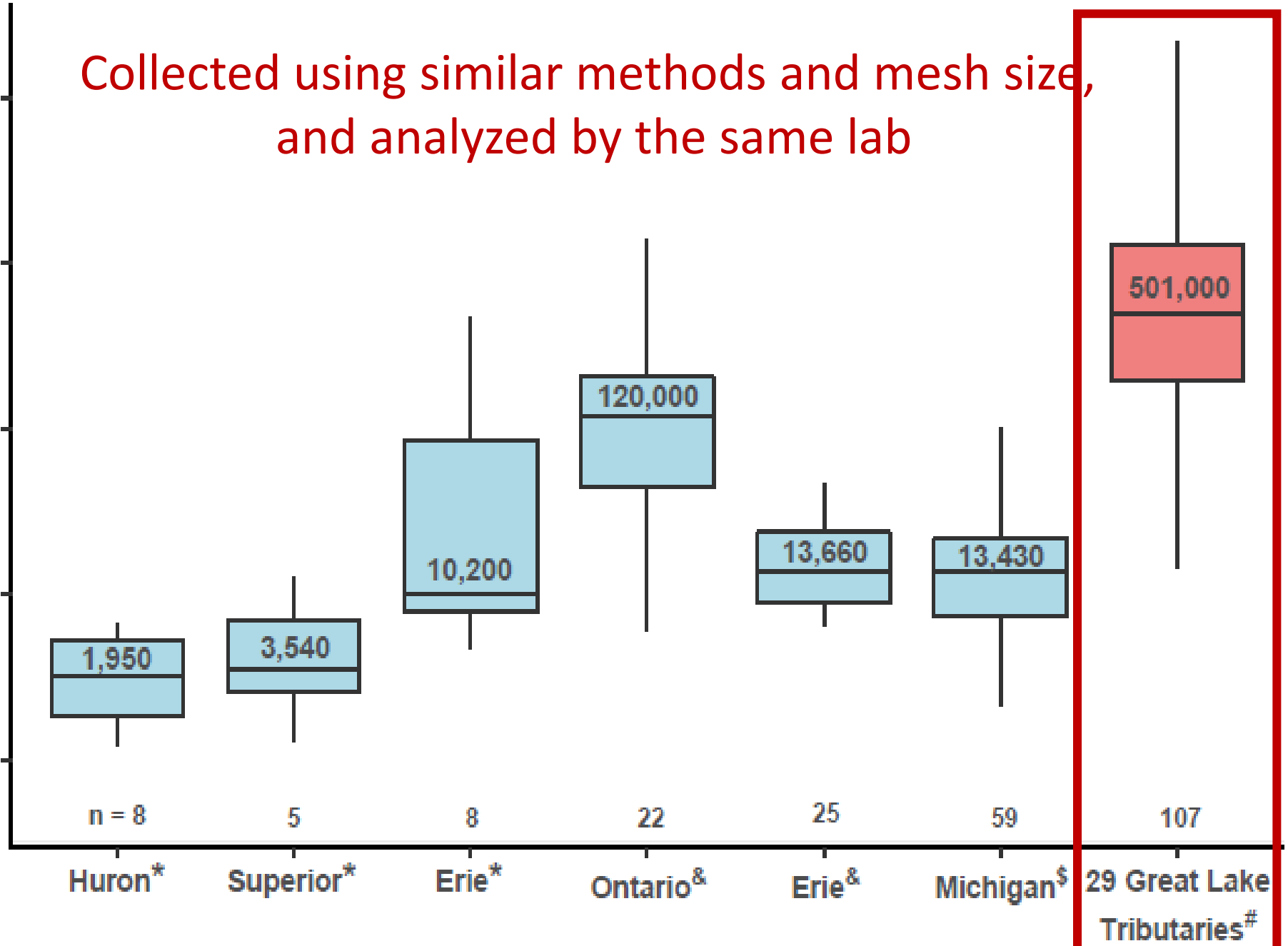


SOURCE:
 Baldwin et al.
 (2016)

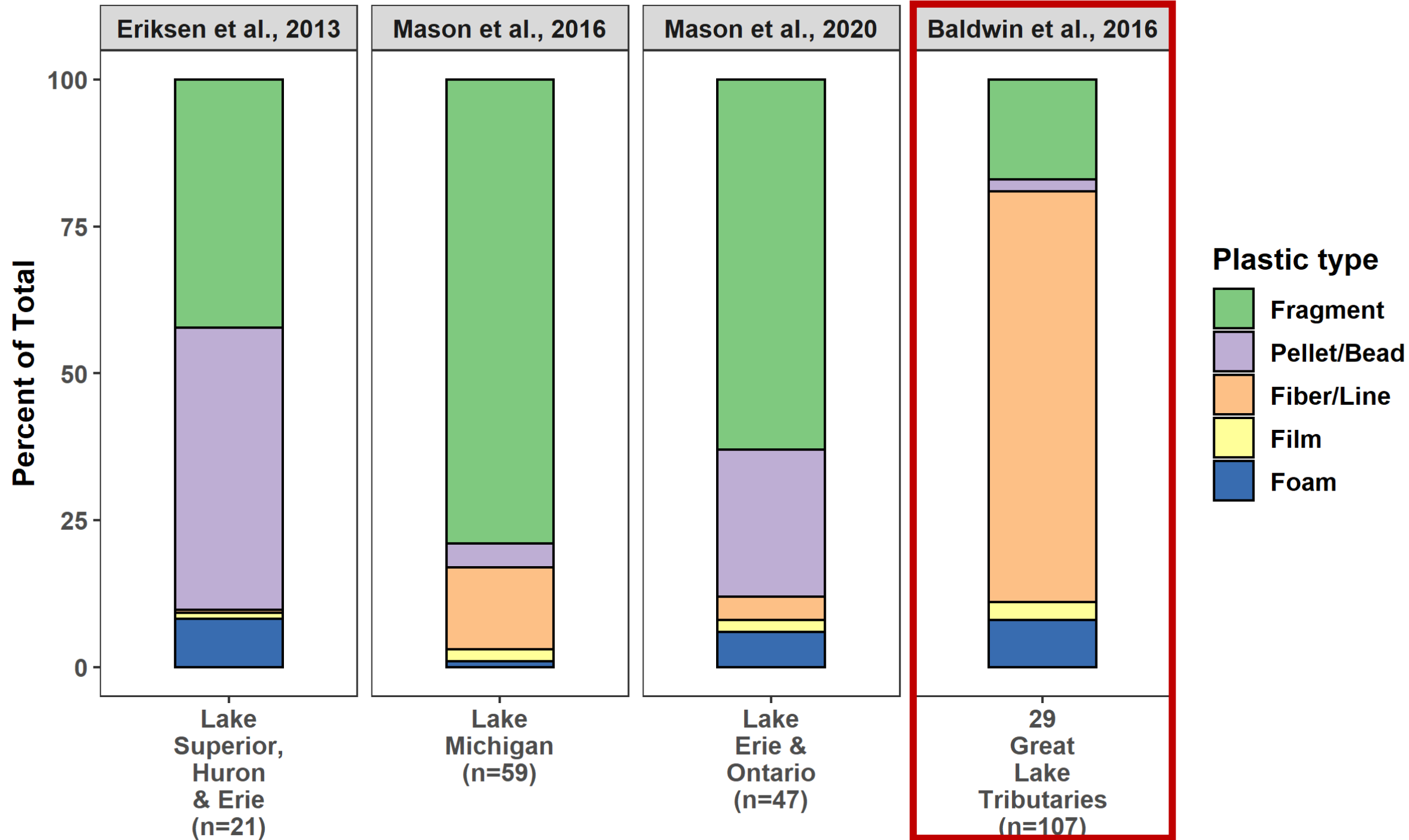
Collected using similar methods and mesh size,
and analyzed by the same lab

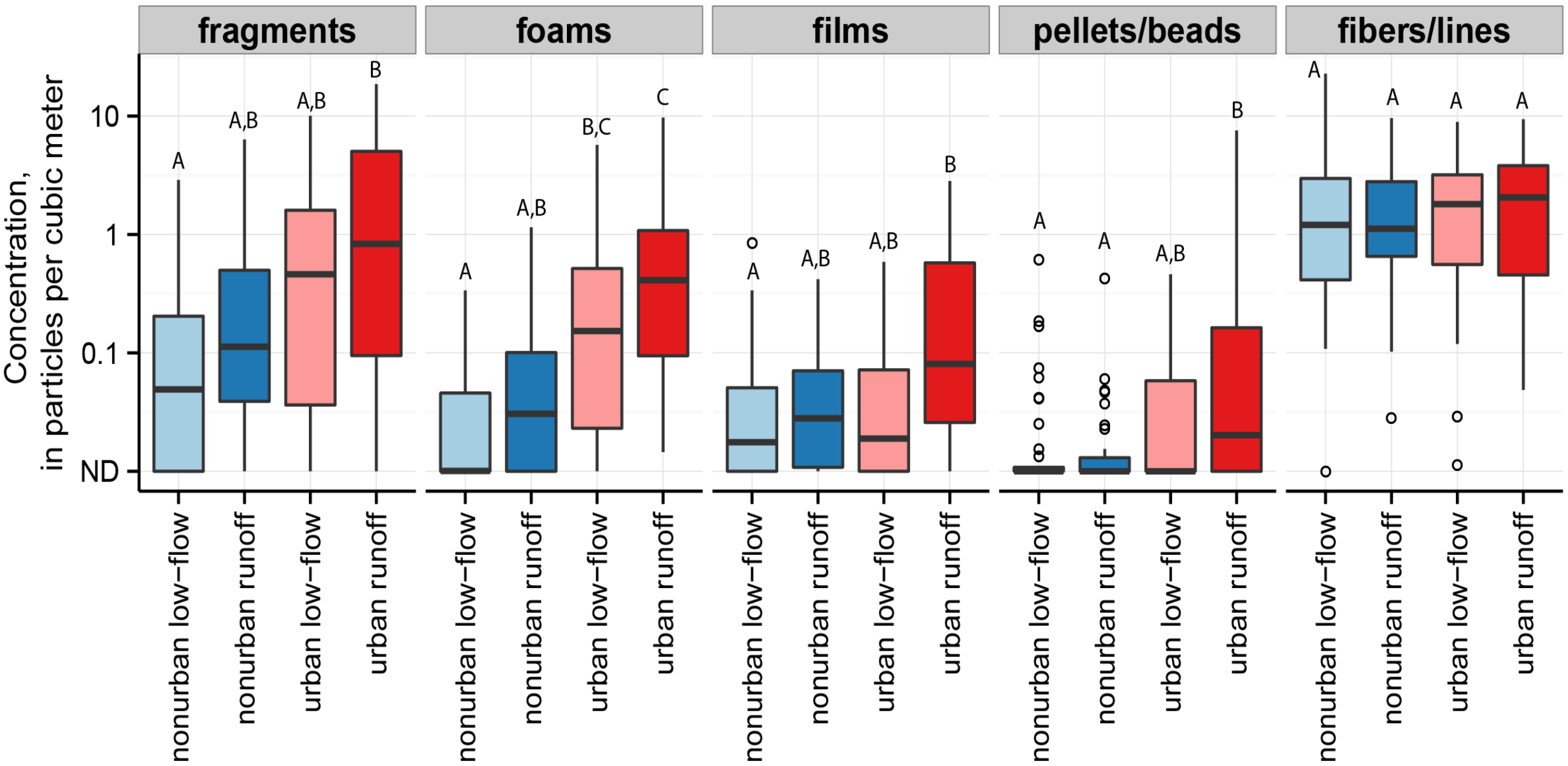
Concentration, in particles
per square kilometer

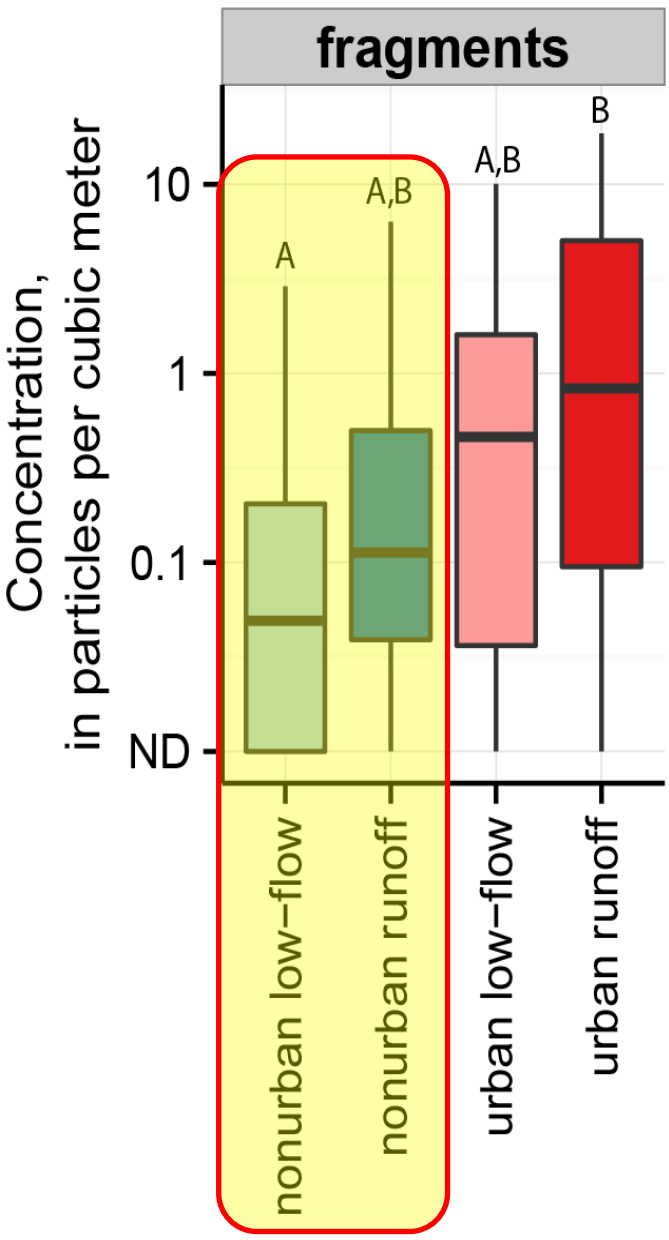
10,000,000
1,000,000
100,000
10,000
1,000

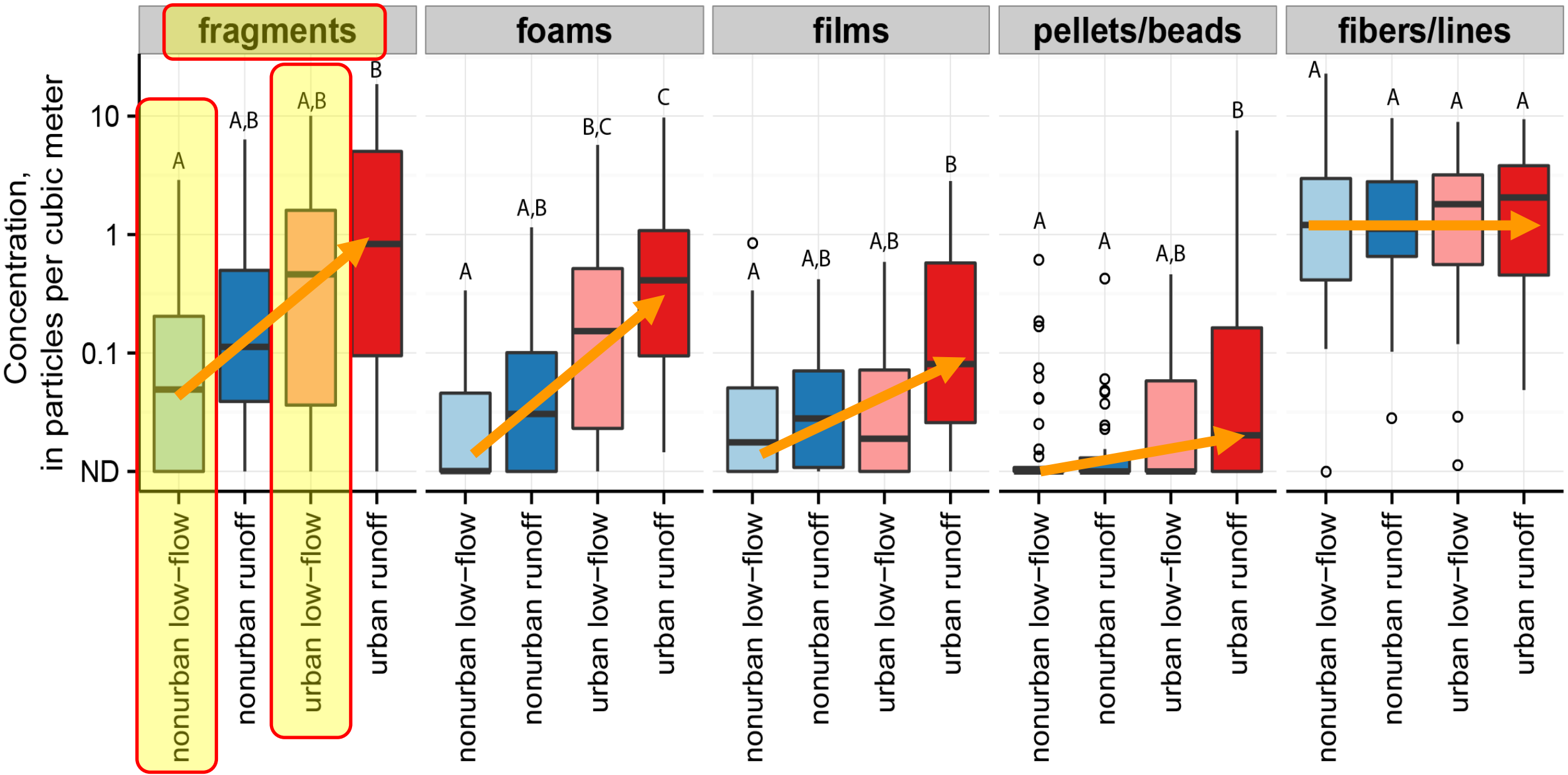


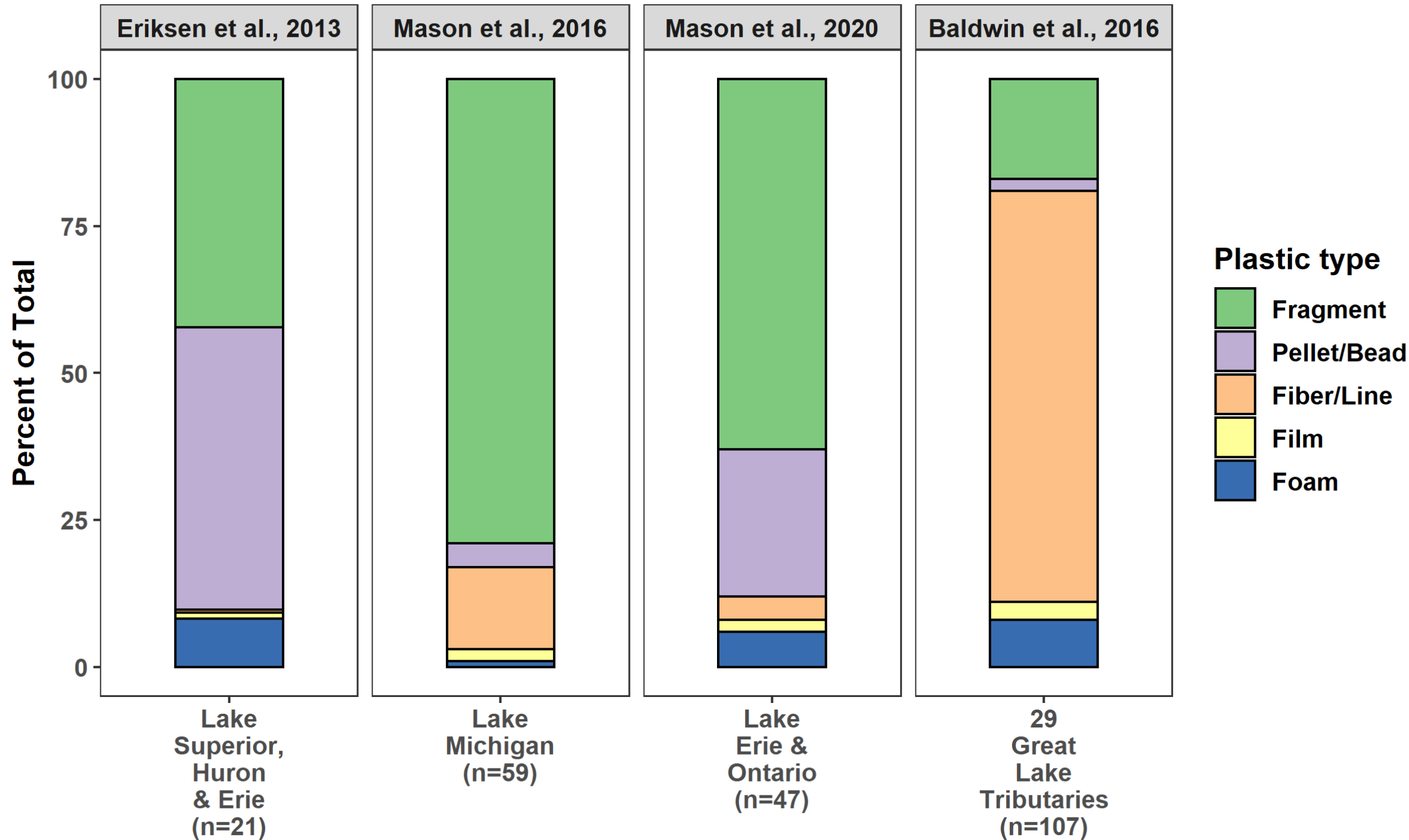
*Eriksen et al., 2013; &Mason et al., 2020; \$Mason et al., 2016; # Baldwin et al., 2016





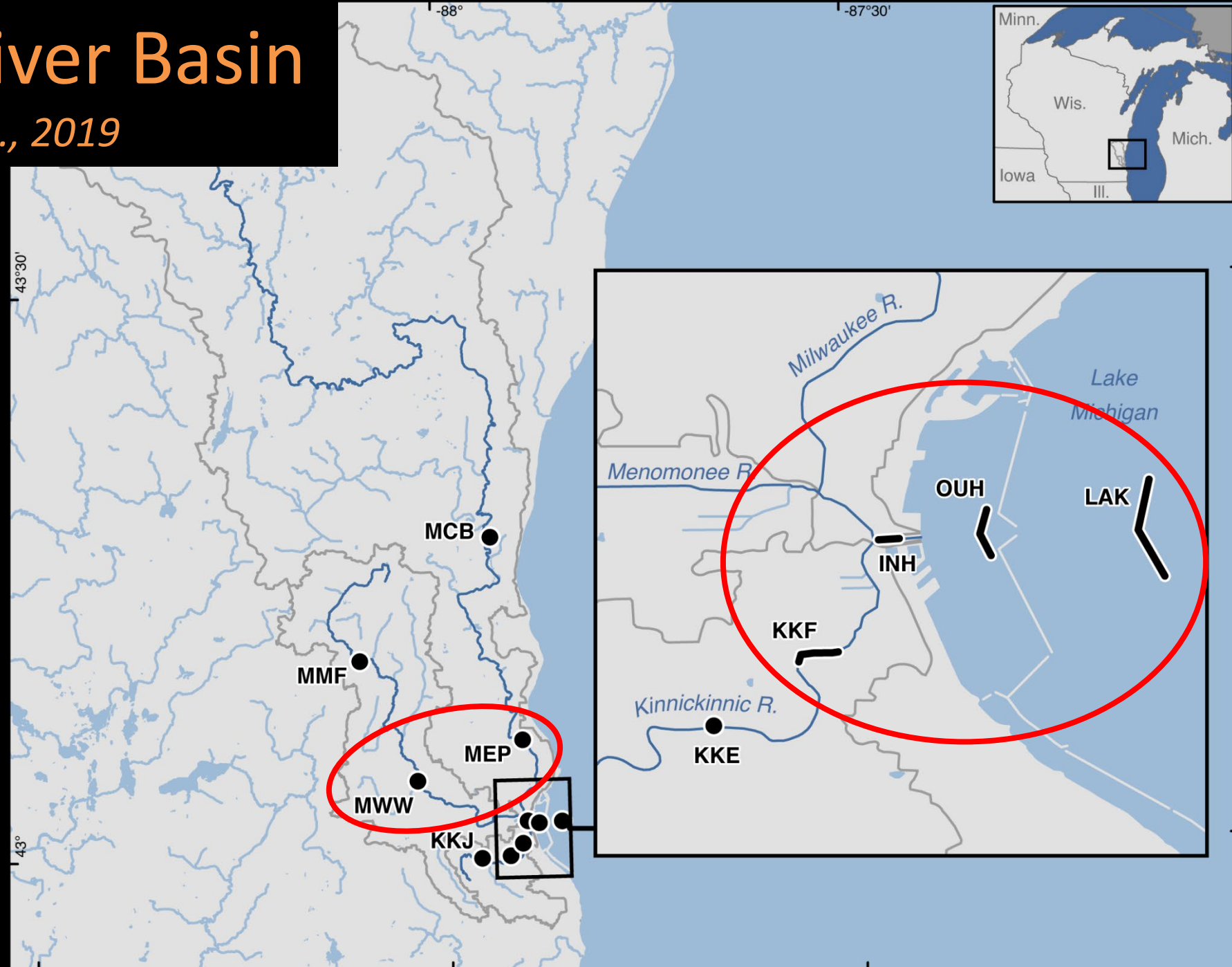






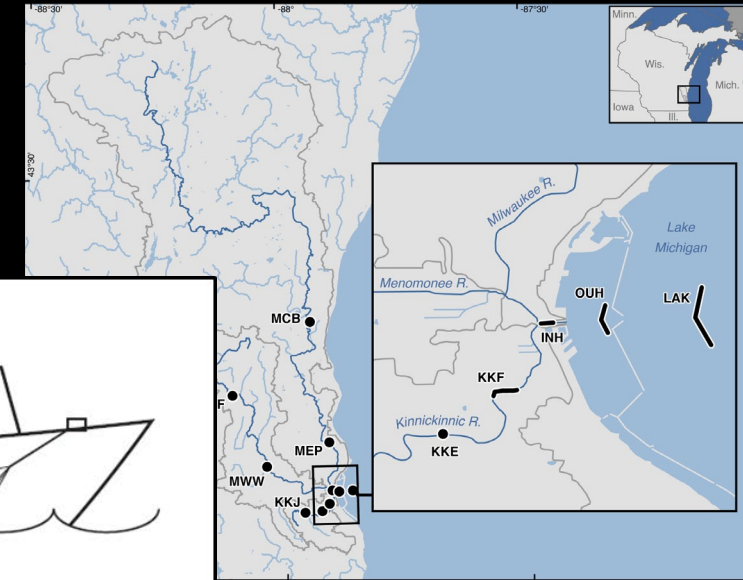
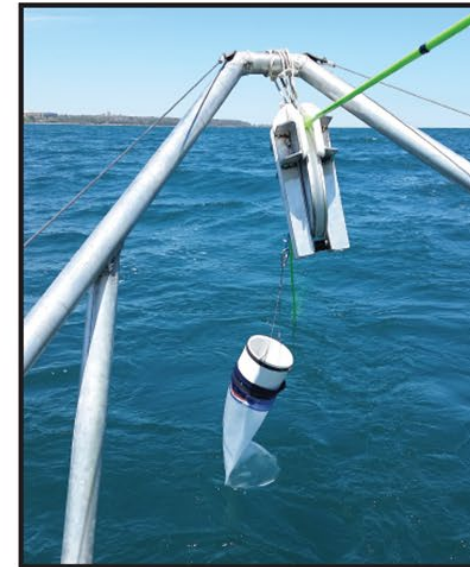
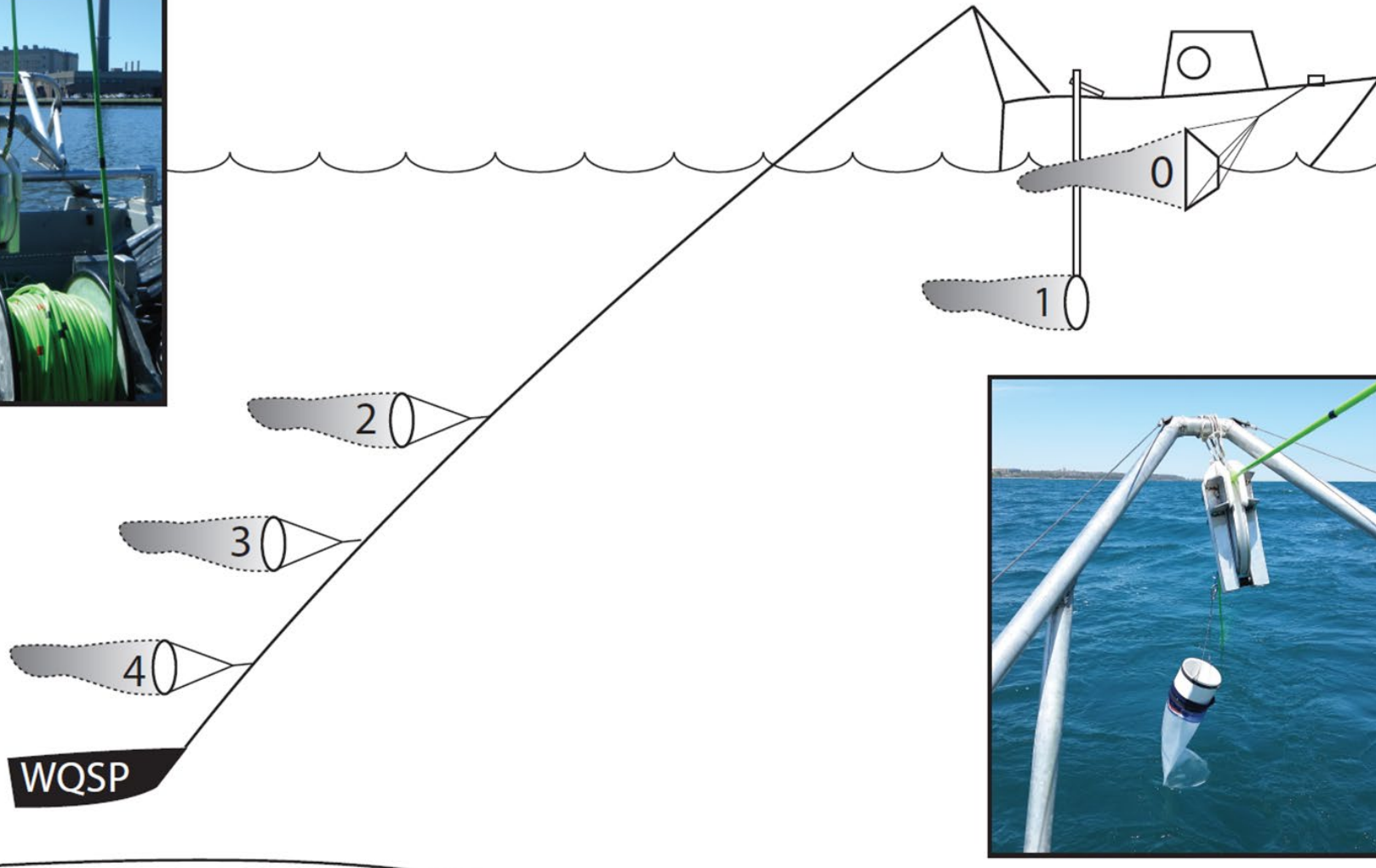
Milwaukee River Basin

Lenaker et al., 2019

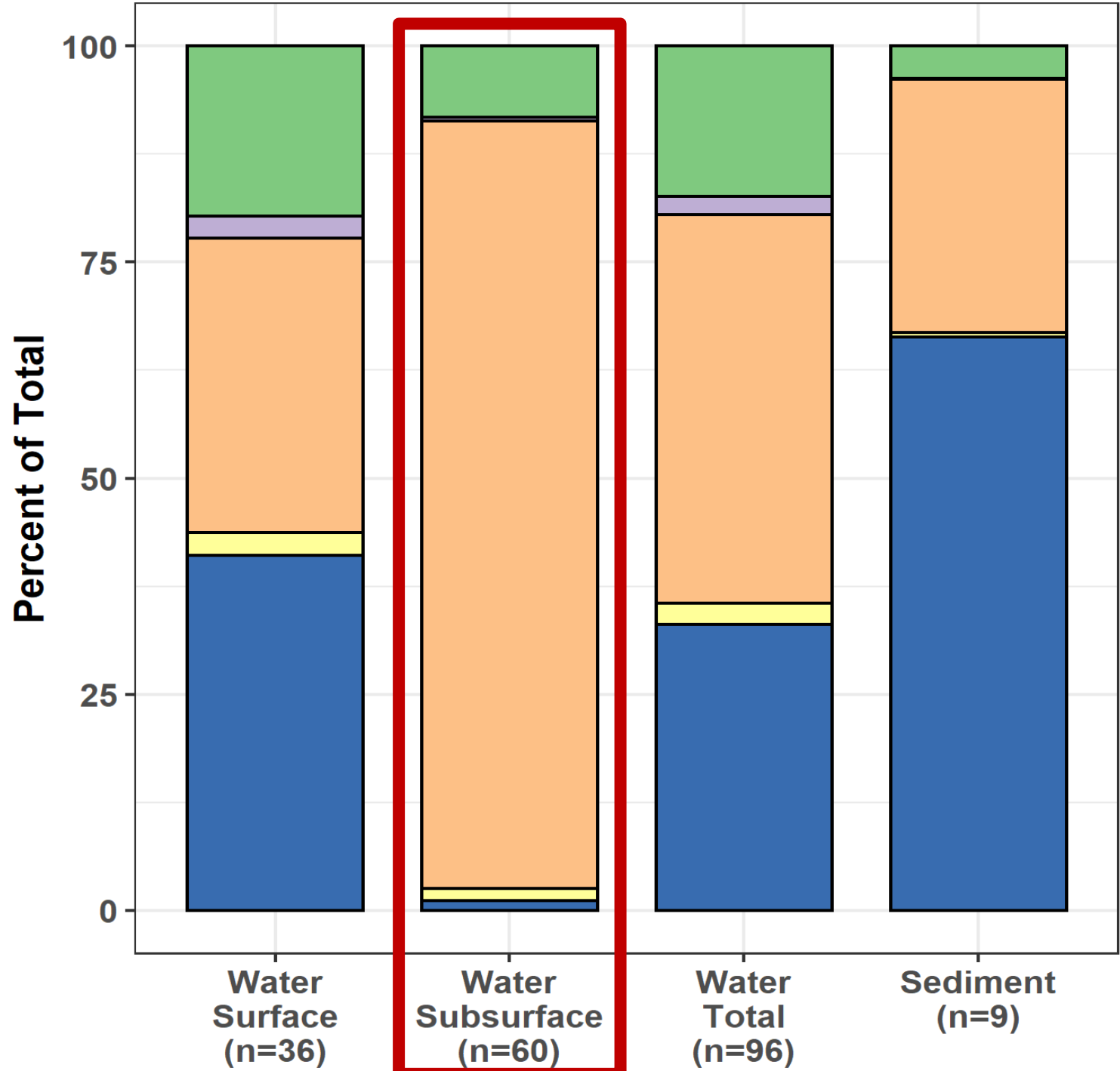


Milwaukee River Basin

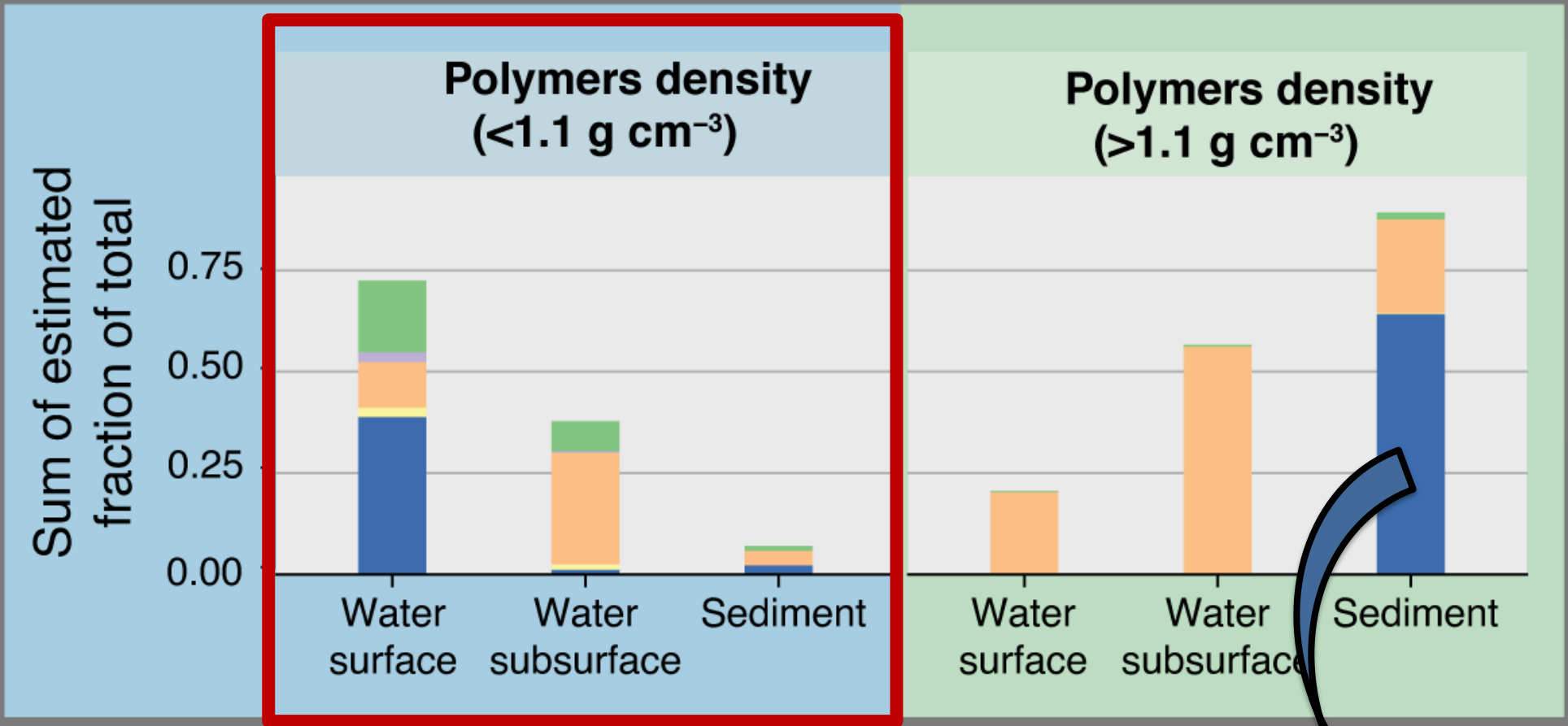
Lenaker et al., 2019



WQSP: Water Quality Sensor Package

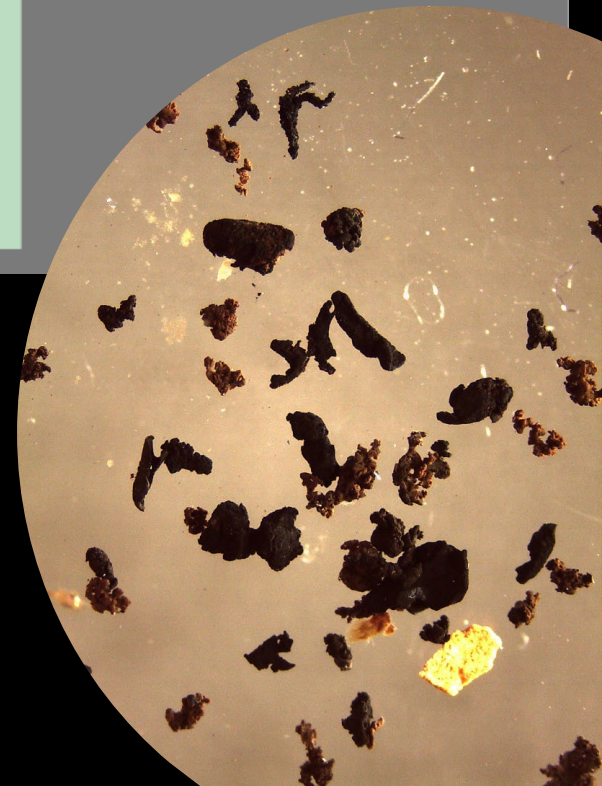


SOURCE: Lenaker et al. (2019)



- Plastic type:**
- Fragment
 - Pellet/bead
 - Fiber/line
 - Film
 - Foam

SOURCE: Lenaker et al. (2019)

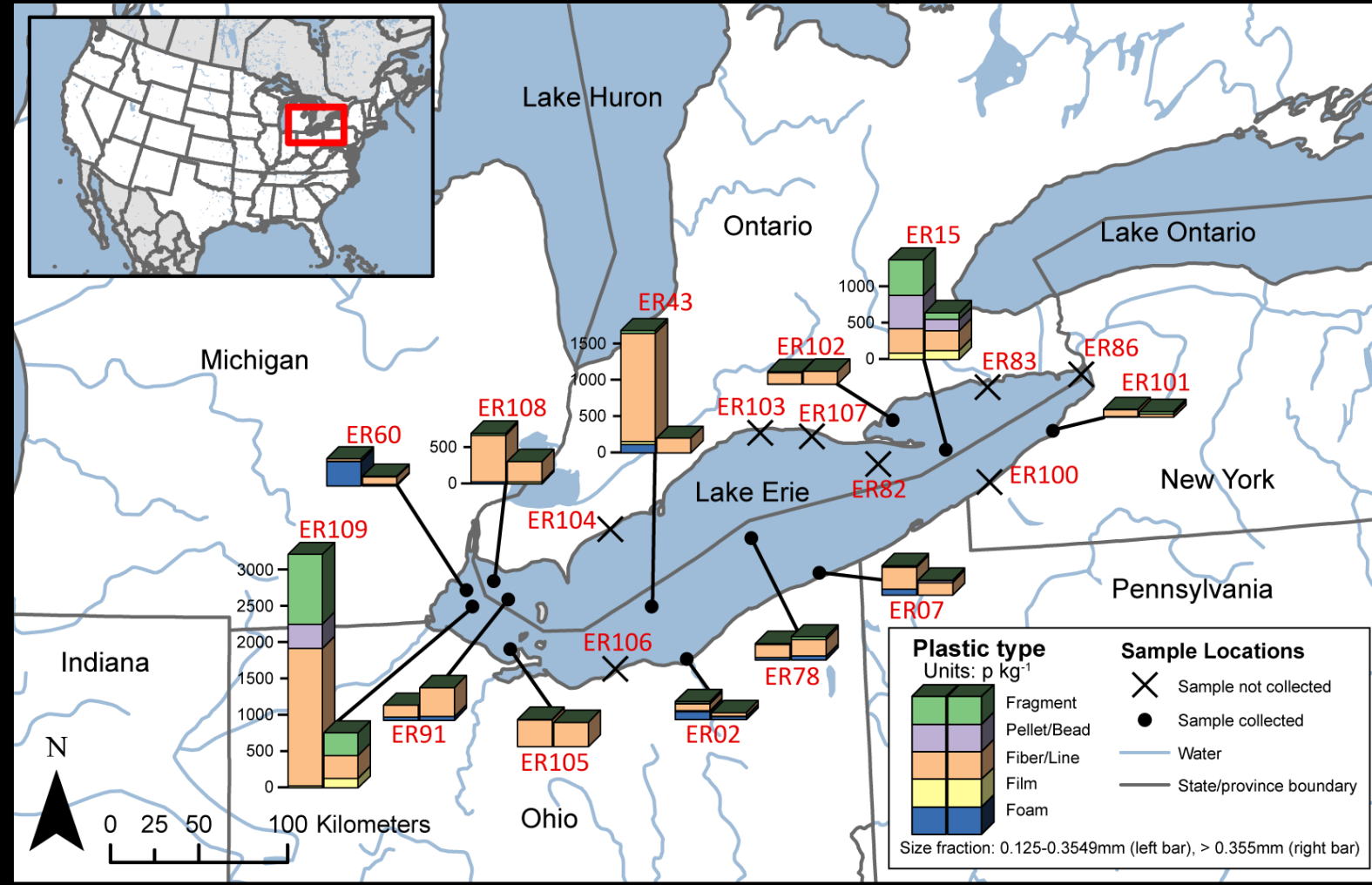
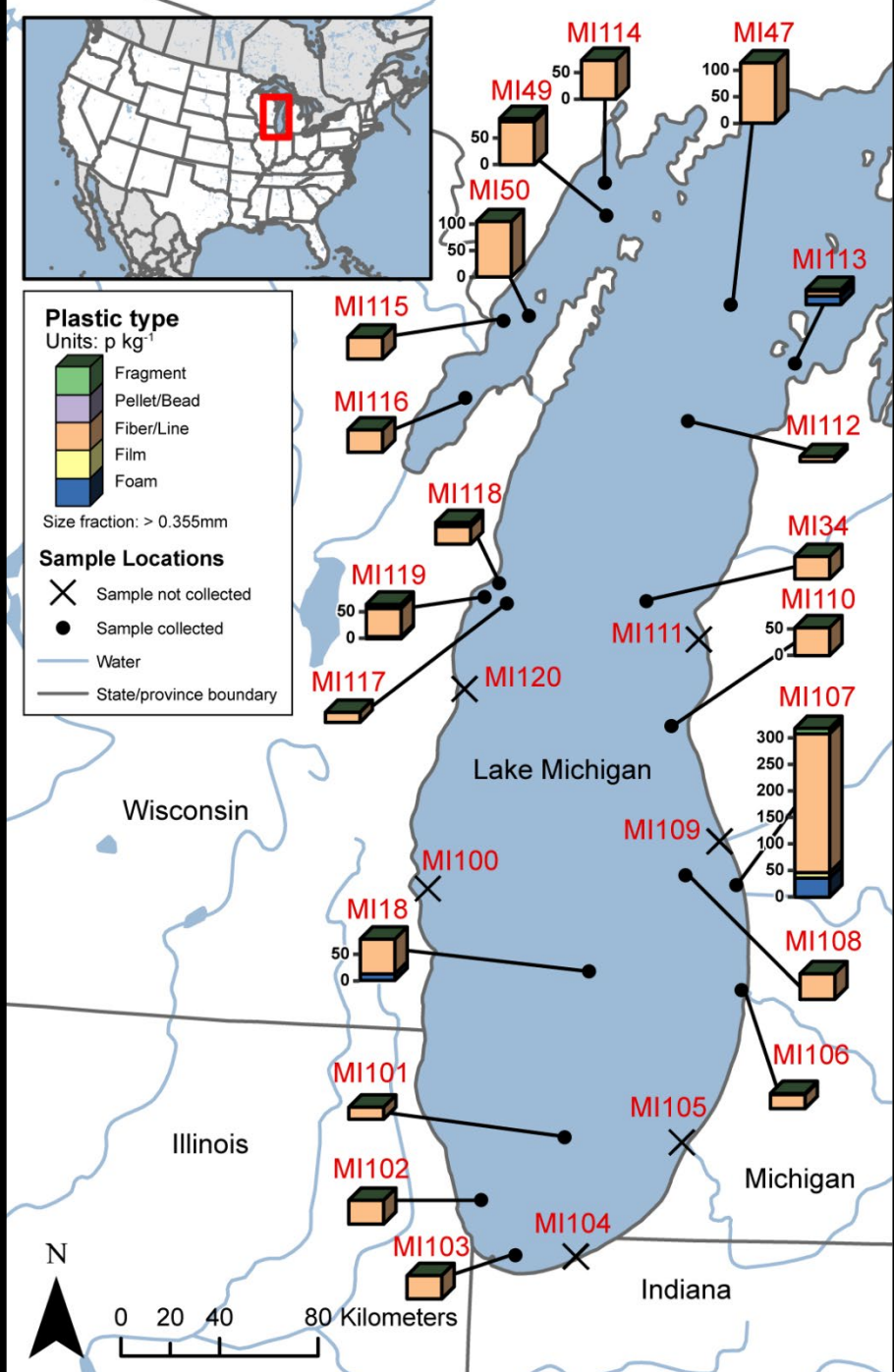


Lake Sediment

A photograph of a lake sediment core sampler on a boat. The sampler is a vertical metal tube with a wooden frame around its base. The water is blue and calm. The boat's deck is visible with red and white pipes and a coiled rope.

Lake Sediment Concentrations

Lenaker et al., 2021





Biota





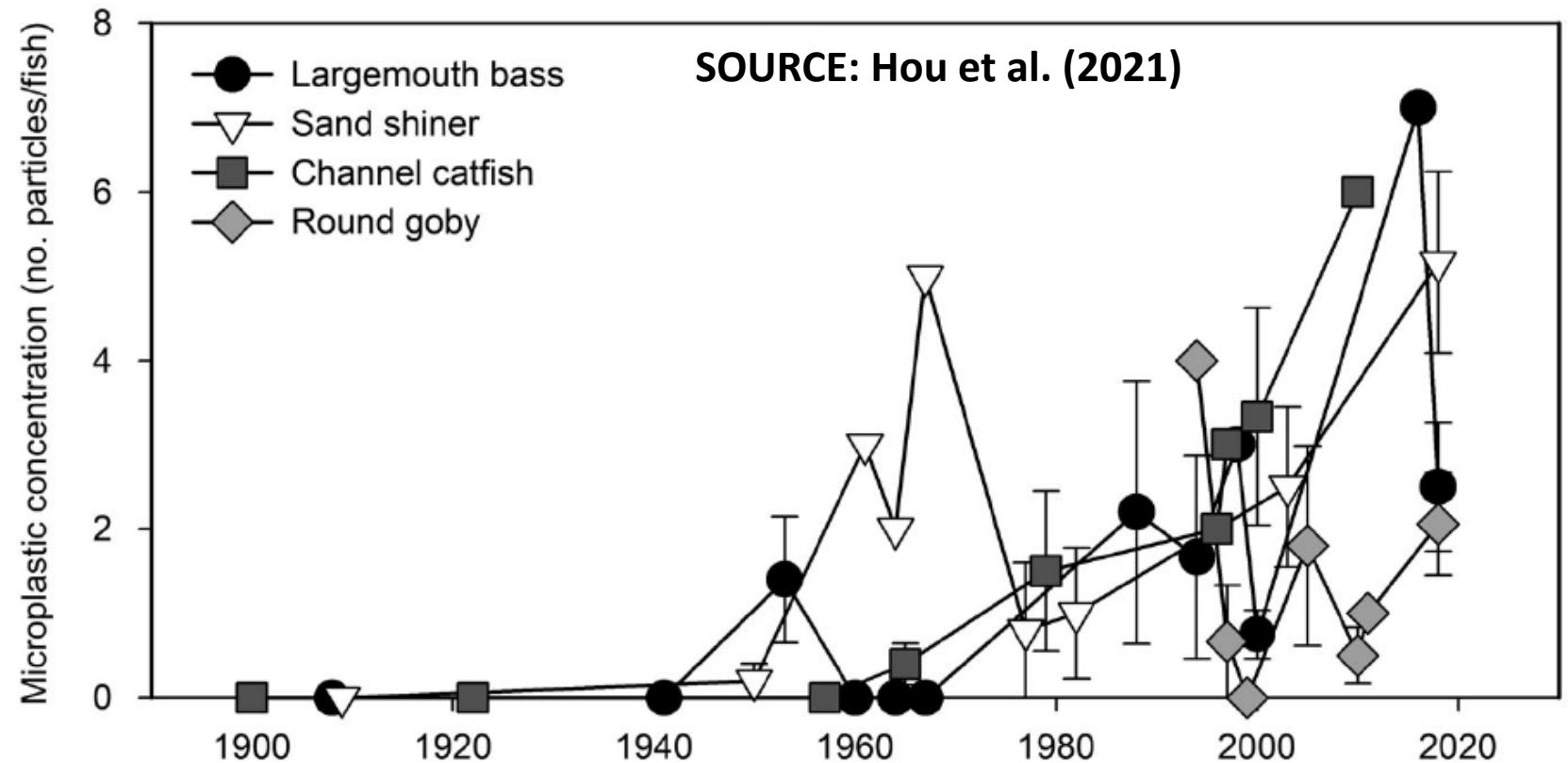
FIBERS DOMINATE

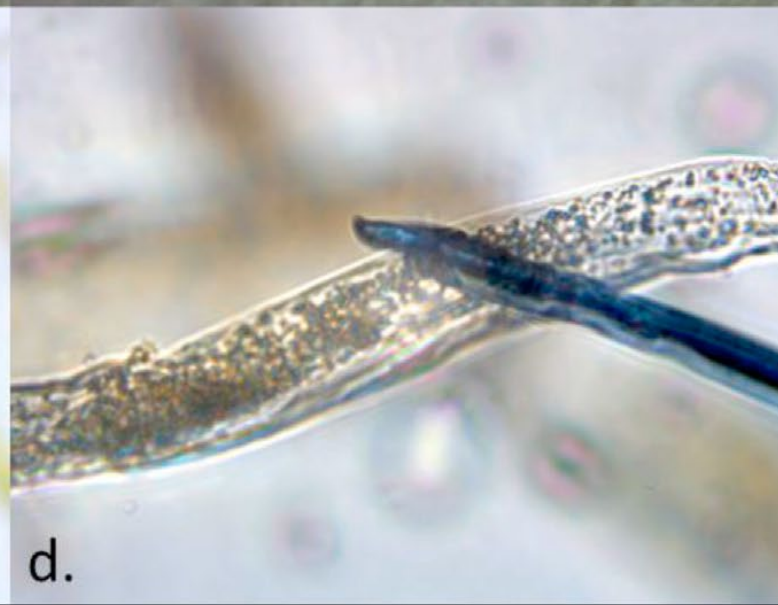
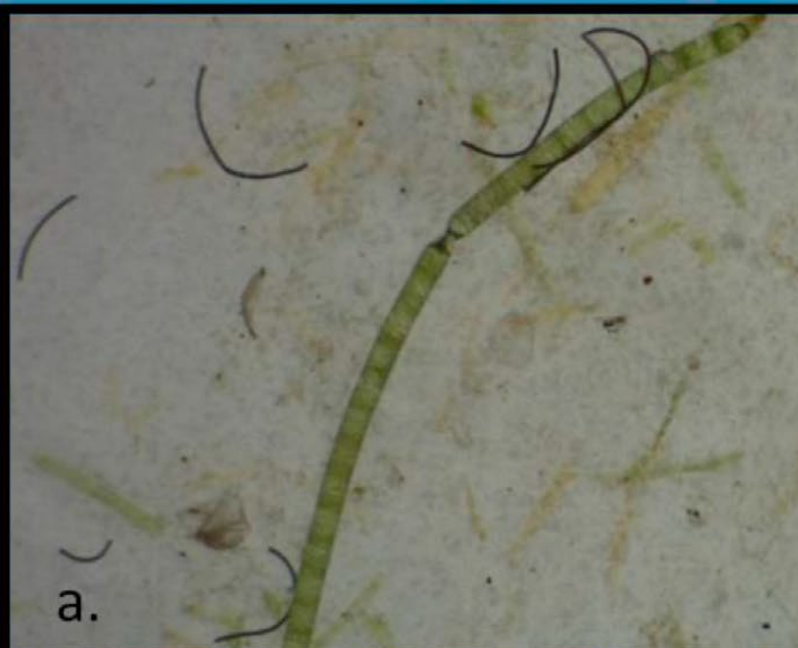
➤ McNeish et al. (2018)

- ❖ 97-100% of particles
- ❖ 10 fish taxa
- ❖ L. Michigan watersheds

➤ Athey et al. (2020)

- ❖ 91% of particles
- ❖ Rainbow smelt
- ❖ L. Huron and L. Ontario





SOURCE: Peller et al. (2021)



MICROPLASTICS IN HUMAN CONSUMABLES

Human Consumption of Microplastics

Kieran D. Cox,^{*,†,‡,§} Ga
and Sarah E. Dudas^{†,‡,§}

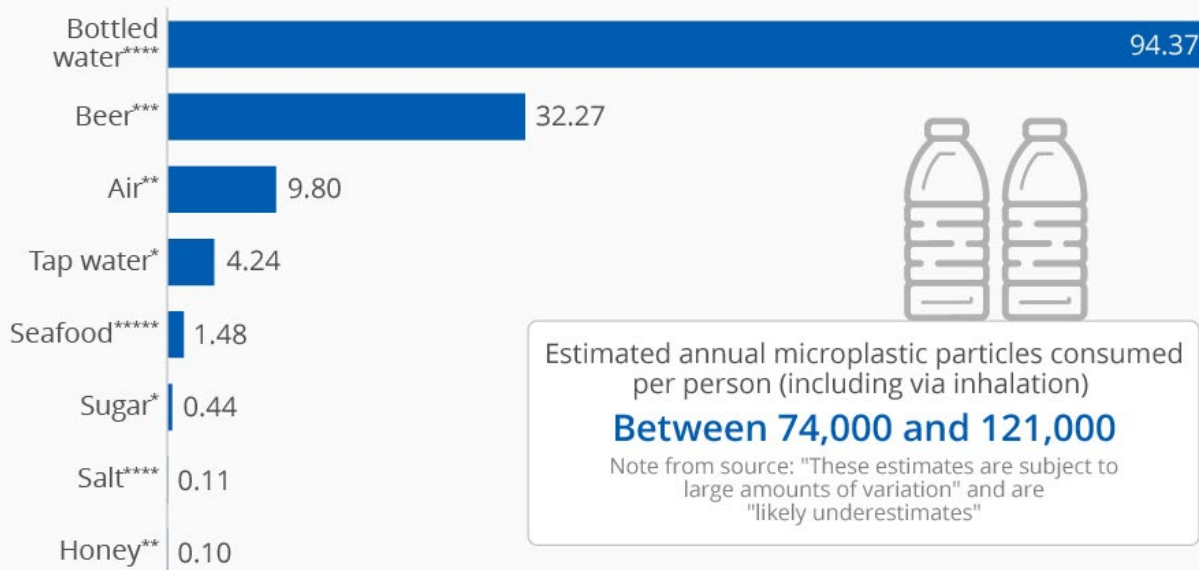
[†]Department of Biology, Unive

[‡]Hakai Institute, Calvert Island

[§]Fisheries and Oceans Canada,

How We Eat, Drink and Breathe Microplastics

Average number of microplastic particles found per gram/liter/m³ of selected consumables



Estimated annual microplastic particles consumed per person (including via inhalation)
Between 74,000 and 121,000
Note from source: "These estimates are subject to large amounts of variation" and are "likely underestimates"

* Based on 1 study
** Based on 2 studies
*** Based on 3 studies
**** Based on 4 studies
***** Based on 14 studies

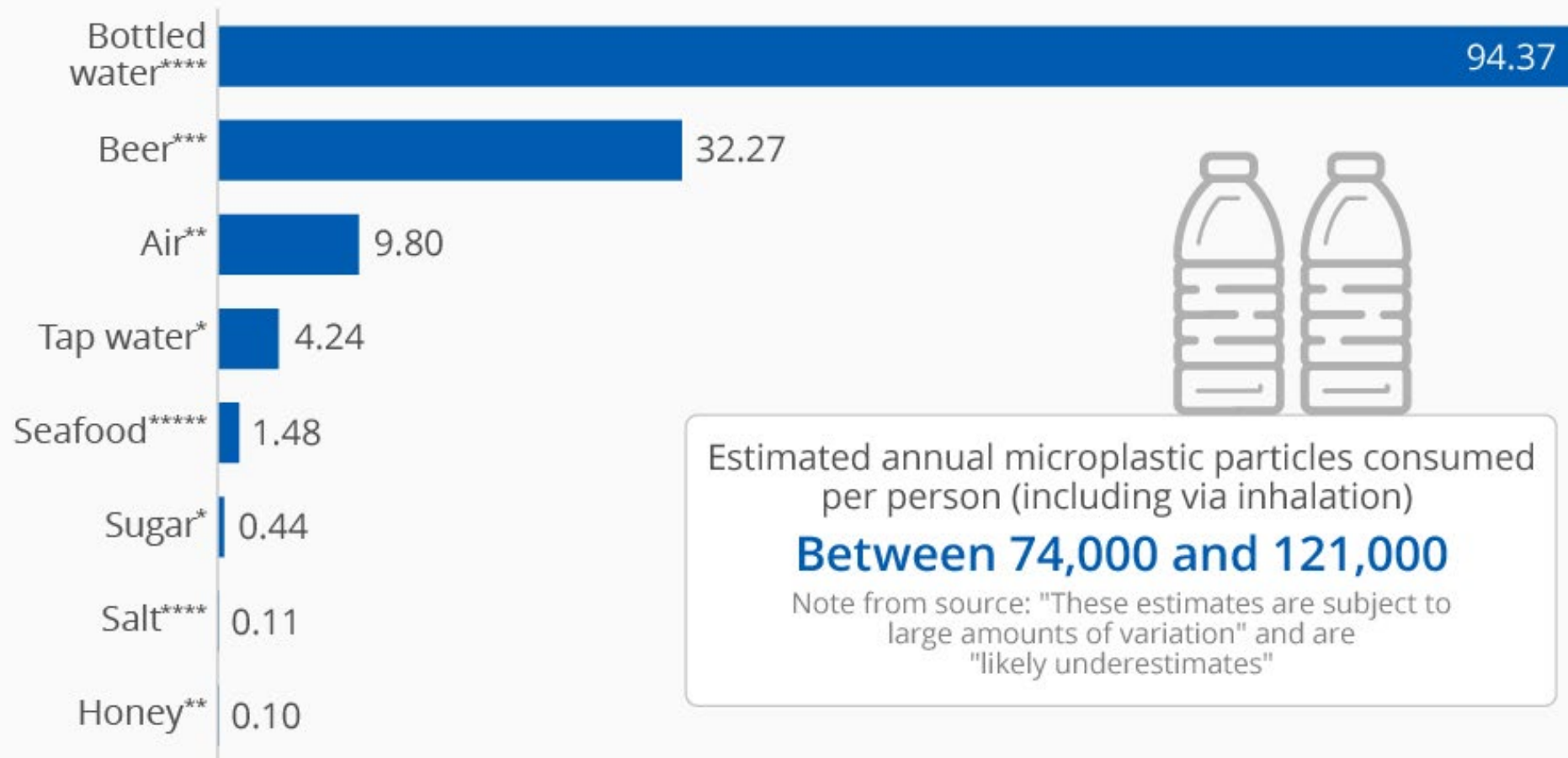
[†] Francis Juanes,[†]

anada



How We Eat, Drink and Breathe Microplastics

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- ** Based on 2 studies
- *** Based on 3 studies
- **** Based on 4 studies
- ***** Based on 14 studies



@StatistaCharts

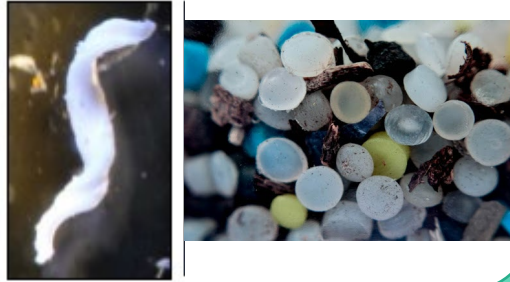
Source: 'Human Consumption of Microplastics', Cox et al. in Environmental Science & Technology (2019)

SOURCES

Mismanaged Waste
(Litter)



Industrial



Textile



In-Use Product



PATHWAYS

Rivers



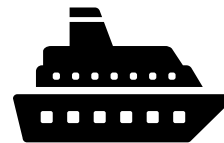
Wind



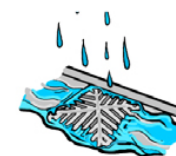
Atmospheric
Deposition



Direct Input



Runoff
(e.g., Urban,
Ag, Industrial)



Treated or
Untreated
Wastewater



Knowledge Gaps

- **Understand Major Pathways**
 - atmospheric deposition
 - stormwater vs. wastewater
 - mass-balance models
- **Address Environmental Compartments with Little Data**
 - air
 - biota
- **Degradation Kinetics**
 - macro (land) → micro (water) ?
 - biodegradable alternatives (e.g. PLA)
- **Ecological Impact**
 - bioaccumulation
 - human health



Thank You!



QUESTIONS?



In a first, microplastics found in human poop

As microplastics permeate remote places and species around the globe, people are no exception.

Smithsonian MAGAZINE

Baby Poo Has Ten Times More Microplastics Than Adult Feces

The small pilot study included fecal samples from ten adults and six infants in New York state



Elizabeth Gamillo
Daily Correspondent
September 28, 2021

Plastics

This article is more than 9 months old

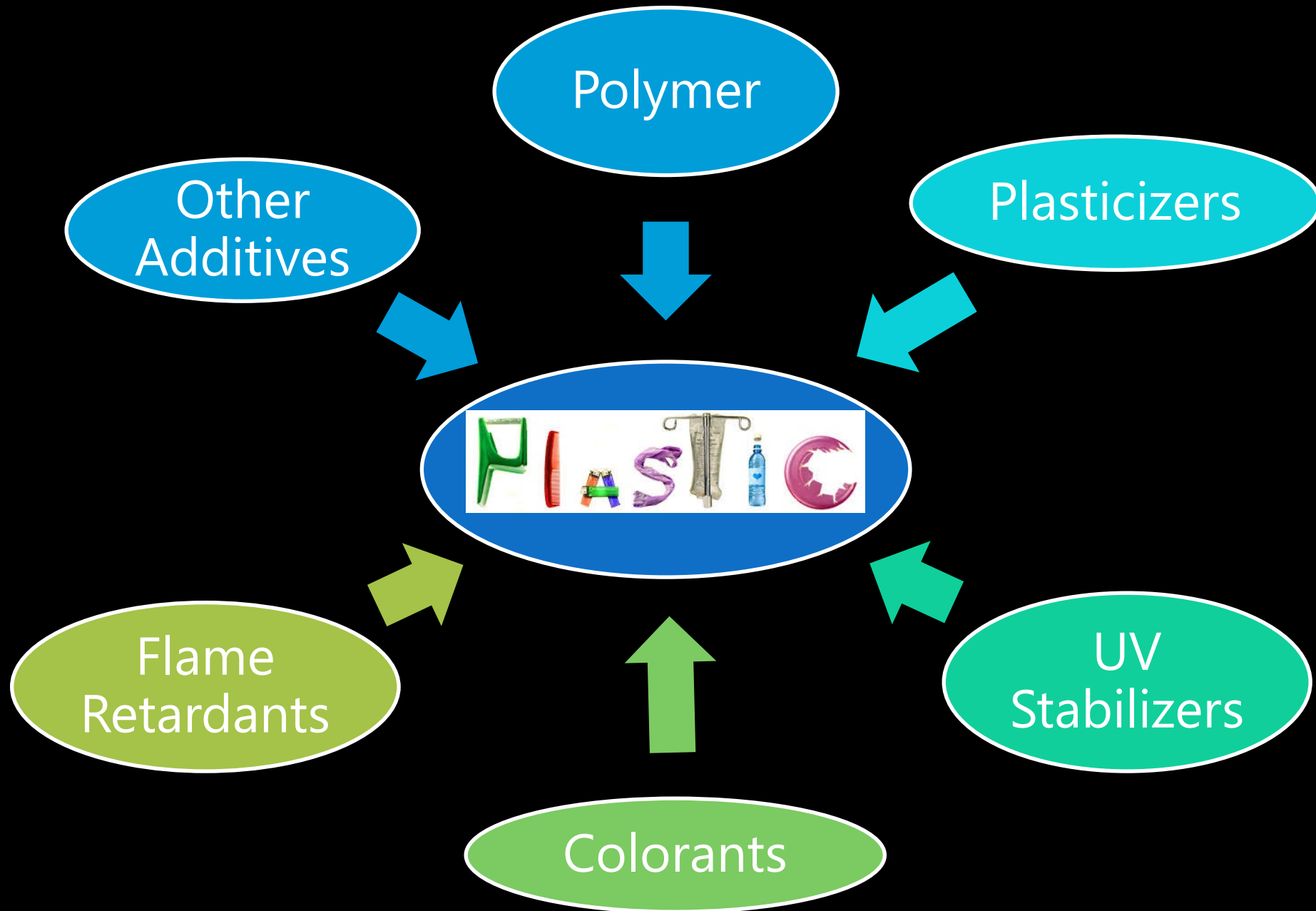
Microplastics revealed in the placentas of unborn babies

Health impact is unknown but scientists say particles may cause long-term damage to foetuses



▲ One charity said: 'Babies are being born pre-polluted.' Photograph: Zffoto/Getty Images/iStockphoto

Microplastic particles have been revealed in the placentas of unborn babies for the first time, which the researchers said was “a matter of great concern”.





Known Human Health Impacts



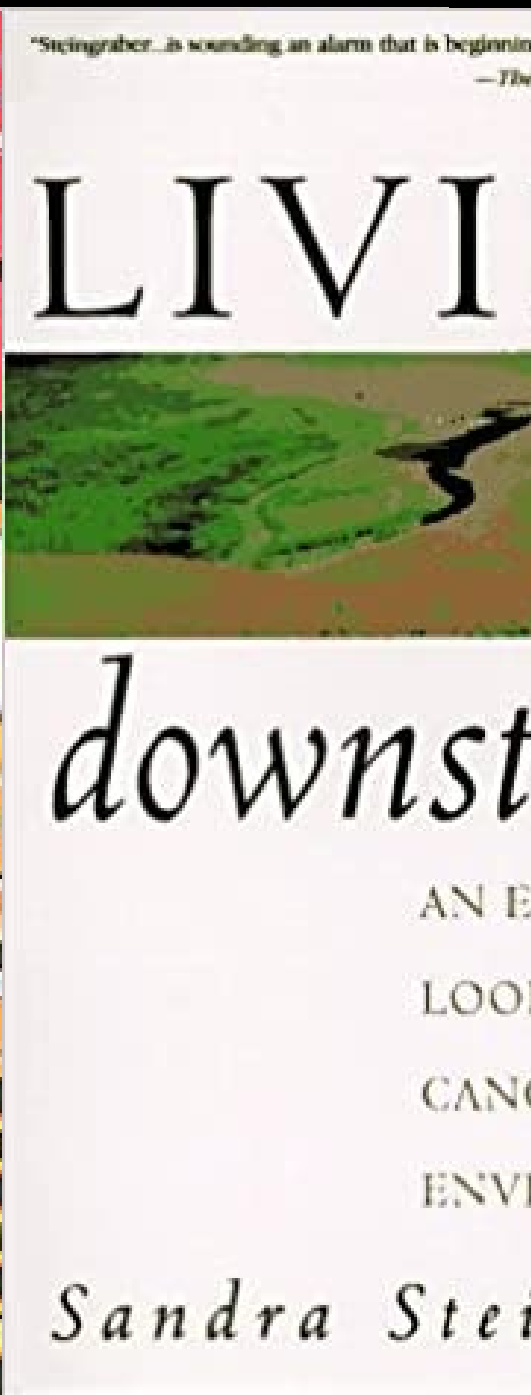
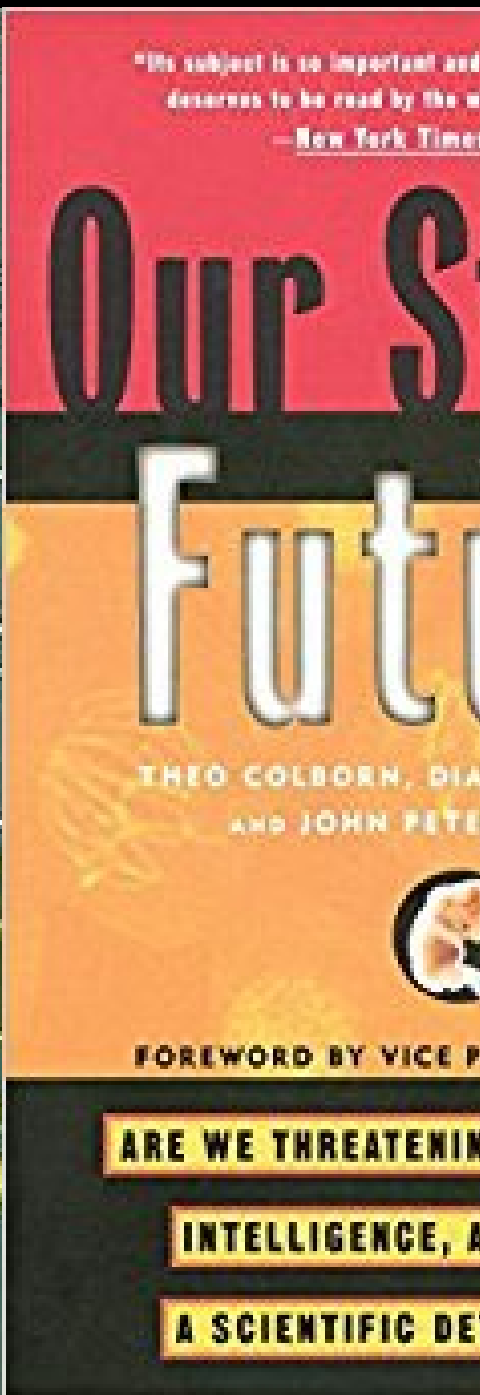
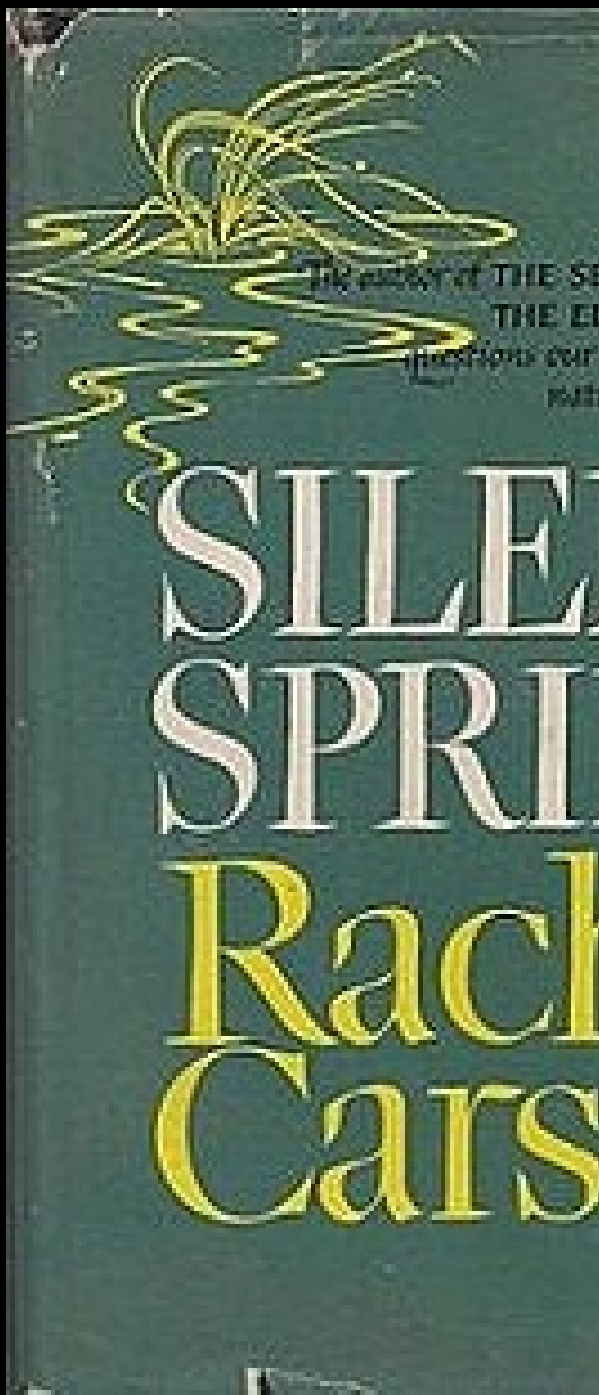
 Sperm Count Zero

Sperm Count Zero

BY DANIEL NOAH HALPERN
September 4, 2018



A strange thing has happened to men over the past few decades: We've become increasingly infertile, so much so that within a generation we may lose the ability to reproduce entirely. What's causing this mysterious drop in sperm counts—and is there any way to reverse it before it's too late?



How Our Modern World Is
Threatening Sperm Counts,
Altering Male and Female
Reproductive Development,
and Imperiling the Future
of the Human Race

COUNT DOWN

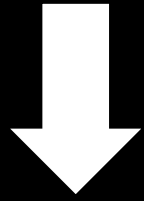
Shanna Swan, PhD
with Stacey Colino

The background is a solid red color. A black staircase graphic descends from the top left towards the center, ending in a downward-pointing arrow. The text is in yellow and black.

An aerial photograph of a wastewater treatment plant. The image shows several large circular aeration tanks in the foreground, some with mechanical scrapers. In the background, there are various industrial buildings, pipes, and storage tanks. A body of water is visible in the upper left corner, and a road or railway line runs along the right side of the facility. The overall scene is a complex of infrastructure for water treatment.

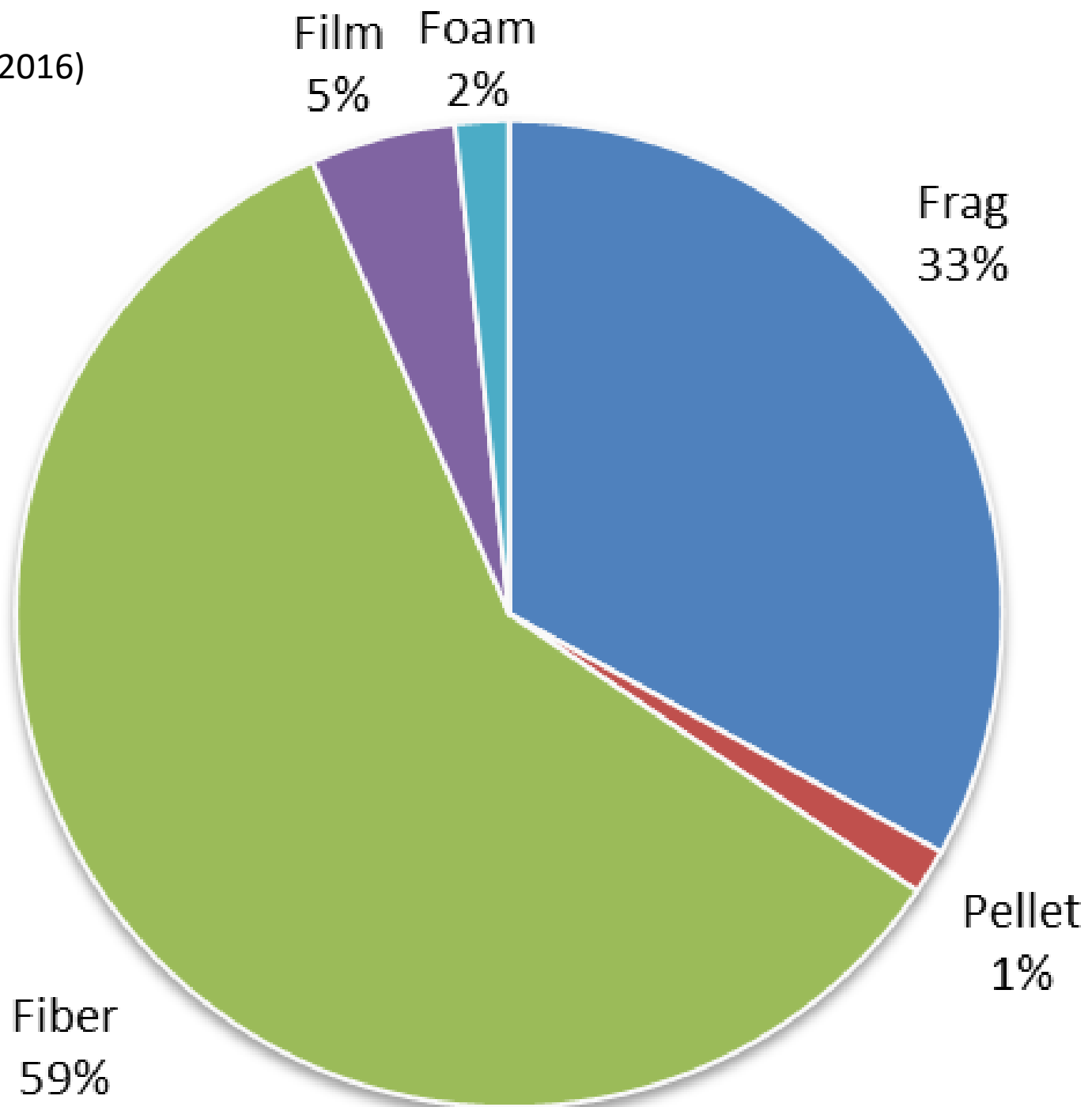
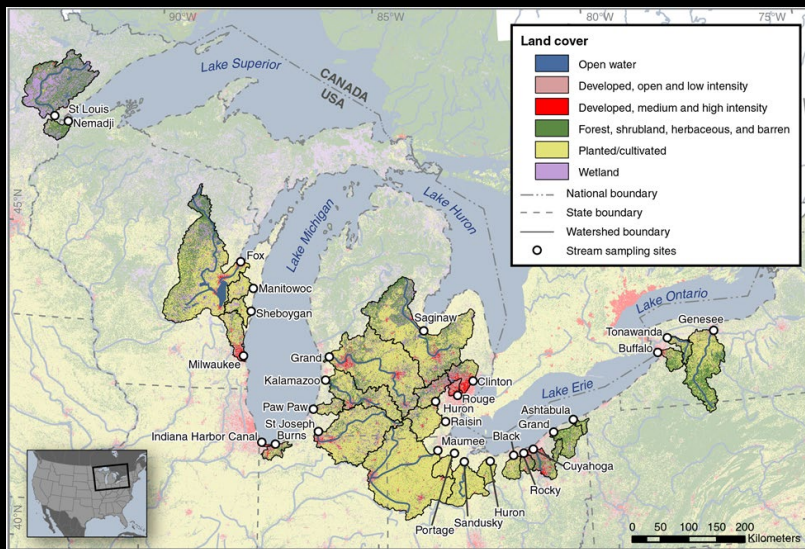
Wastewater Treatment Plants

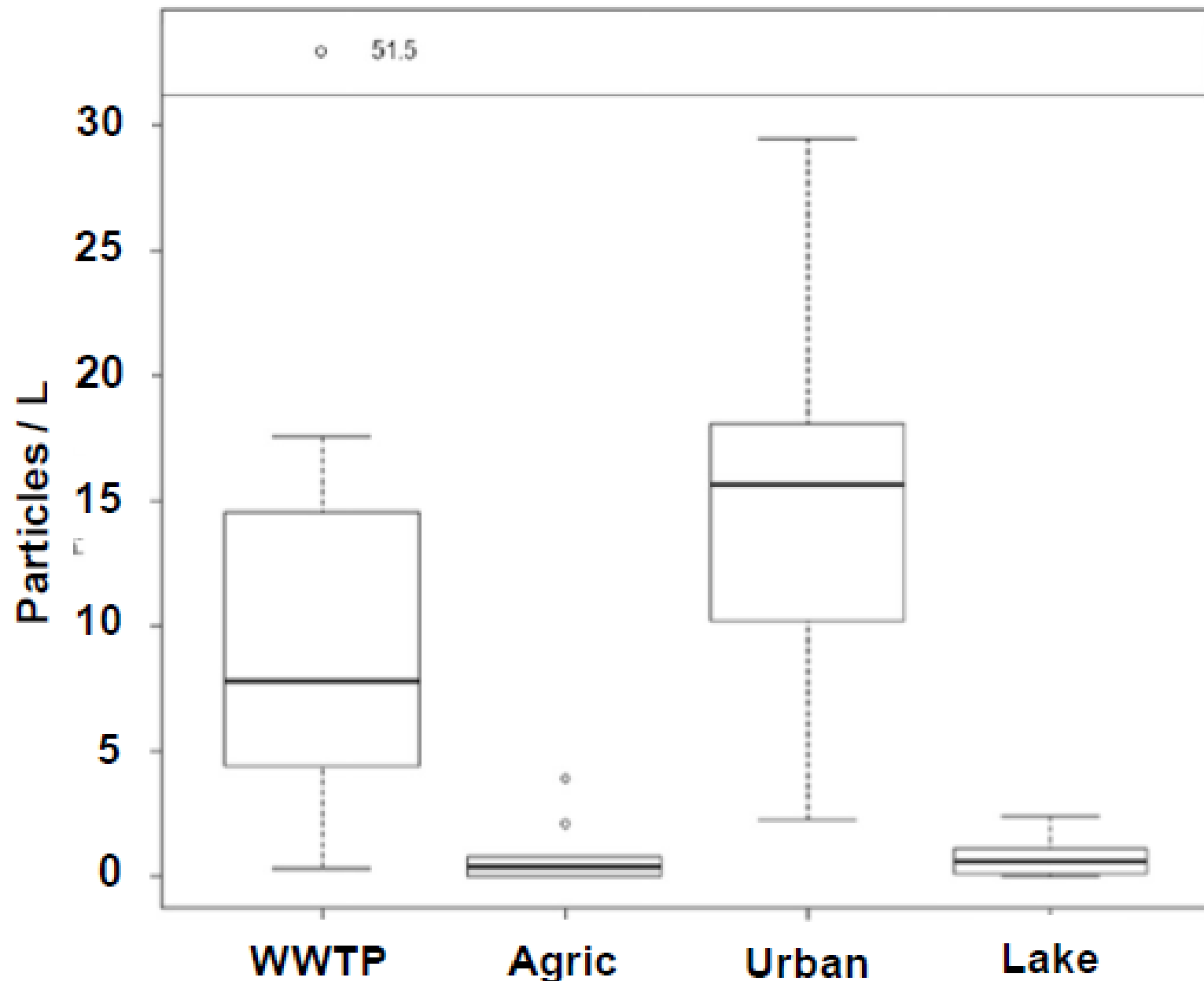
WWTP



> 4 million particles/day

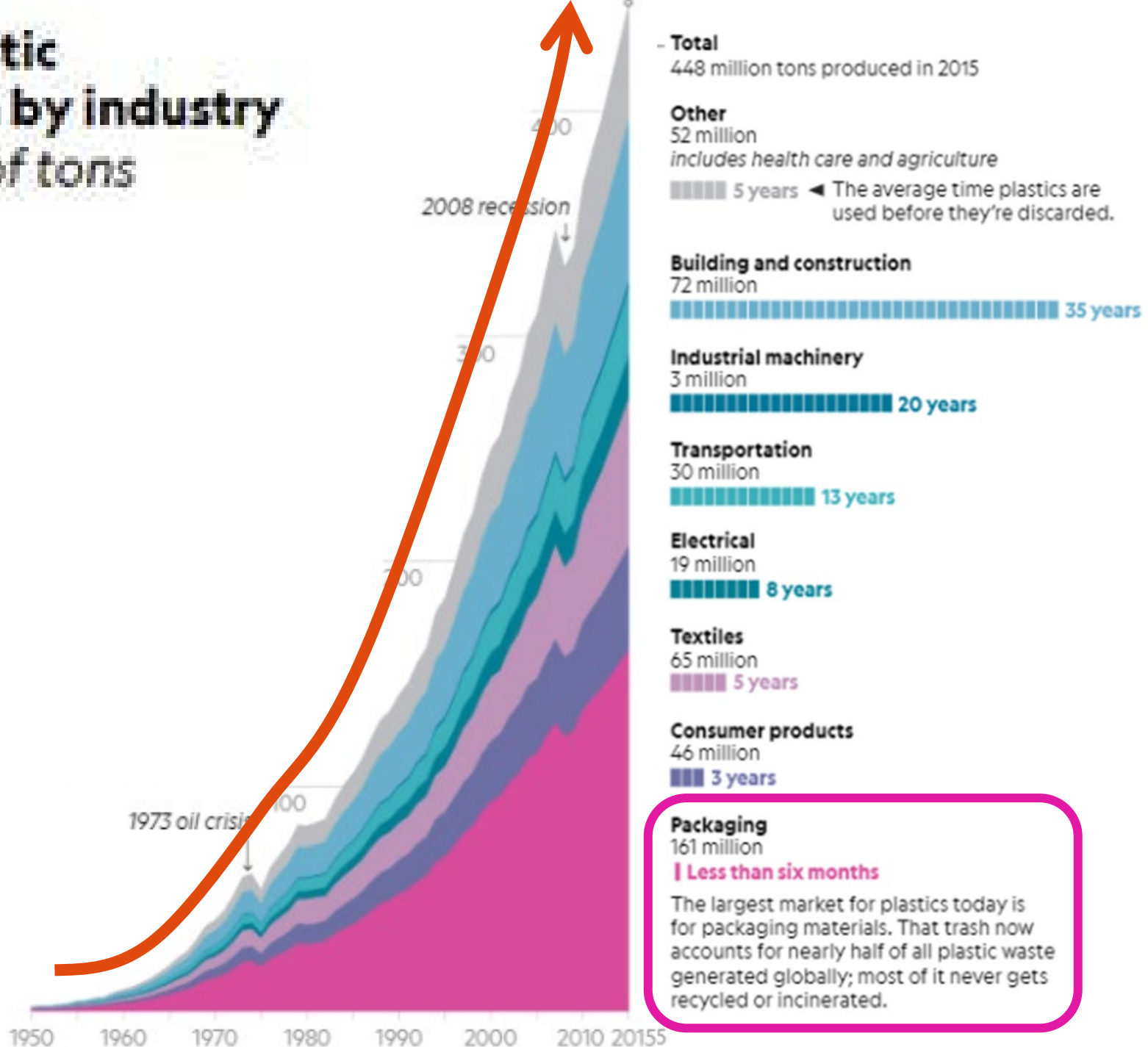
SOURCE:
Mason et al. (2016)





Grbic et al., 2020 Water Research

Global plastic production by industry in millions of tons



Packaging
161 million
Less than six months

The largest market for plastics today is for packaging materials. That trash now accounts for nearly half of all plastic waste generated globally; most of it never gets recycled or incinerated.

Jason Treat & Ryan T. Williams, National Geographic

Source: Roland Geyer, University of California, Santa Barbara

Packaging

161 million

| Less than six months

The largest market for plastics today is for packaging materials. That trash now accounts for nearly half of all plastic waste generated globally; most of it never gets recycled or incinerated.